
LEFT
彩
照
姓名：Name
职务：Post
单位：Unit
No: Date:
002
装得快 文具
APRIL2013
24ColorCard CameraTrax.com

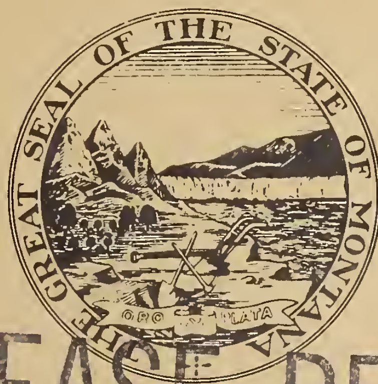
…VE TECHNOLOGIES REPORT

FOR

SOLID WASTE DISPOSAL

AND

RESOURCE RECOVERY



FOR

STATE OF MONTANA

SOLID WASTE MANAGEMENT

AND

RESOURCE RECOVERY STUDY

AUGUST, 1976 FINAL REPORT

HENNINGSON, DURHAM & RICHARDSON

ENGINEERING • ARCHITECTURE • PLANNING • SYSTEMS • ECONOMICS

HELENA, MONTANA

ATLANTA · CHARLOTTE · CHICAGO · DALLAS · DENVER · LOS ANGELES · MINNEAPOLIS · NEW ORLEANS · NORFOLK, VA
OMAHA · PENSACOLA · PHOENIX · SANTA BARBARA · SEATTLE · WASHINGTON, D C

REPORT NO. 3

ALTERNATIVE TECHNOLOGIES REPORT

FOR

SOLID WASTE DISPOSAL AND RESOURCE RECOVERY

FOR

STATE OF MONTANA

SOLID WASTE MANAGEMENT

AND

RESOURCE RECOVERY STUDY

AUGUST, 1976

FINAL REPORT

This report was prepared for the Montana Department of Health and Environmental Sciences Solid Waste Management Bureau

TABLE OF CONTENTS

TABLE OF CONTENTS - Cont'd

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS - Cont'd

LIST OF FIGURES - Cont'd

SUMMARY

This report is the third in a series of major reports that will be published in conjunction with the Solid Waste Management and Resource Recovery Study for the State of Montana. This report summarizes the technical and operating requirements and costs for the various solid waste processing, utilization and disposal alternatives applicable in the state at the present time. The alternatives are divided into four main categories: (1) sanitary landfills, (2) transfer stations, (3) processing facilities and (4) utilization facilities.

Generally, costs were determined for several size facilities. For sanitary landfills the range was from a minimum size operation for a small community to a landfill which would receive 2000 tons of waste per week. Present State Solid Waste Laws and Regulations require that the waste deposited at a landfill must be covered with soil the same day it is deposited. The costs included in this report are based on each site complying with these regulations.

It was determined that the disposal cost per ton varies greatly depending on the quantity of waste being disposed of. For example, the cost to operate a sanitary landfill which serves a population of 200 people varies from $189 to $124 per ton depending upon the number of days the landfill is open. This compares to a cost of approximately $2.50 per ton for a sanitary landfill serving 100,000 people. It should be noted however, that at the present time very few waste disposal sites in the state practice covering the waste at the end of each day. Thus, the actual disposal costs which are being incurred at the majority of the disposal sites in the state are substantially less than those shown in this report.

A detailed analysis of the technical and operating requirements and the associated costs of utilizing transfer stations to reduce the costs of transporting and disposing of solid waste is included in Part Three of this report. In the transfer station concept the solid waste hauled in several vehicles is consolidated into one large load for transportation to a disposal site using a larger, more efficient vehicle. The trend toward the use of transfer stations has led to the development of equipment specifically suited for this need.

For the State of Montana, it was determined that three general types of transfer stations are applicable. Figures III-1 through III-5 illustrate the building and equipment requirements of each. As illustrated, the simpler stations which serve small populations, basically consist of small containers placed on strategic locations where local residents can deposit their waste. The containers are then loaded onto special collection vehicles and transported to a disposal site. For larger population centers, more sophisticated stations are required. In these stations, waste is deposited in an enclosed building where mechanical equipment is used to transfer and compact the waste into large transfer vehicles. The capital and annual operation costs for various size transfer stations

were computed and are summarized in Tables III-1 to III-4. The capital costs vary from $17,000 for a small rolloff container system to approximately $412,000 for a station which has the capability of handling the waste generated by 100,000 people.

The third alternative analyzed was to include some degree of solid waste processing in conjunction with subsequent disposal or resource recovery. The degree of processing is dictated by the demand and markets for the recoverable components and by the subsequent use of the processed waste. An in-depth analysis of the potential market situations in the state were discussed in the second report for this project, entitled "Energy and Secondary Materials Market Report." That report is on file with the State Solid Waste Management Bureau.

Based on the current market situations and a review of the available processing technology, it was determined that three degrees of processing could be required to prepare solid waste for the potential recovery applications in the state. The descriptions and costs of these processes are included in Part Four of this report. The three degrees vary from shredding and extracting the ferrous metals to a complex process in which the wastes are subjected to two stages of shredding, magnetic separation and air classification. The capital and annual operation costs of the three basic processing plants are summarized in Part Four of this report. The capital costs vary from $1.8 million to $5.2 million depending upon the degree of processing.

The fourth alternative analyzed in this report is the technical equipment requirements and estimated costs to utilize solid waste, either as an energy source or as a soil conditioner. Three basic waste utilization systems were analyzed. The first system analyzed is the direct combustion alternative whereby solid waste is utilized as a fuel source in a boiler to produce steam and/or generate electricity. In this system processed waste can be utilized either as the primary or as a supplemental fuel. The second potential alternative is pyrolysis whereby solid waste is heated to high temperatures in an oxygen deficient combustion zone to produce a low Btu gas or oil, which can then be utilized as an energy source in place of natural gas or fuel oil. The third alternative is composting whereby solid waste is converted into a usable soil conditioner.

The processing and utilization requirements and applicable costs for each of the three utilization systems are discussed in detail in Part Five of this report. A review of the three basic systems analyzed indicated that the direct combustion alternative is the least expensive alternative both on capital and annual cost basis. Based on the costs developed in this report, steam can be produced from a plant fired predominately with solid waste for approximately $3.20 to $3.75 per thousand pounds. This cost is comparable with the costs the majority of the larger industries in the state are incurring under their present steam generation system.

An analysis of the costs incurred to operate a pyrolysis system(s) in the state are presently not favorable. To offset the capital and operational costs of a 300 ton per day pyrolysis system in Montana, a revenue of approximately $4.25 per MMBtu for the low Btu gas generated would be required. This is two and one half times greater than the present price of natural gas in the state. Based on the high costs, the pyrolysis alternative will not be further considered as a disposal alternative for this project.

Through marketing investigations it was determined that the two composting methods are potentially applicable in the state: (1) the conversion of solid waste into a commercial fertilizer and (2) the use of processed solid waste as a soil conditioner for topsoil replacement at coal strip mines. An analysis of the economics of the three utilization alternatives indicated that the composting alternatives are more expensive than the direct combustion and pyrolysis alternatives. It was also determined that the market value of the resultant compost product is very low. Based on the high capital and operating costs and low marketable value of the product, the alternative of utilizing solid waste as a soil conditioner or commercial fertilizer are not favorable at this time in the state.

PART ONE

INTRODUCTION

PART ONE

INTRODUCTION

A. GENERAL

The primary objective of this report is to identify and evaluate the technical, mechanical and operating requirements and costs of the various solid waste processing, utilization, transfer and disposal alternatives applicable at the present time in the State of Montana. The site layouts and cost estimates included in this report are not site specific but rather are typical illustrations for each alternative. The information included in this report will be used in the next phase of the project where alternative solutions for specific situations will be evaluated.

Within the last ten years, solid waste disposal technology has evolved from a basic collection-haul-landfill or a collect-haul-incineration cycle to a rather large and sometimes confusing array of processing techniques. These unit processes, sub-systems or systems are designed to subject the solid waste stream to shredding and air classification, electromagnetic, heavy media and optical sorting, and final utilization of the combustible fraction in such processes as composting, direct fired energy recovery and pyrolysis.

A careful analysis of this array of systems will indicate that many of the processes are experimental at this time, and are, in effect, emerging technology. However, on the positive side, great strides have been made in combining proven technology and equipment into new systems. Over one hundred processing systems are currently in operation or under construction around the country. These systems receive, shred, in some cases air classify, do elementary metal separation, and in many cases, complete their cycle with a product which can be used as a fuel.

The utilization systems are still emerging and generally follow three major classifications: (1) an energy conversion system by direct combustion, such as stoker fired grate equipped boilers and heat recovery incinerators; (2) pyrolysis systems which convert the combustible fraction into a gas or oil product which can be burned in conventional equipment; and (3) bioconversion, which either develops a burnable pulp or burnable gas, or both. Several of these systems have emerged as a result of laboratory research or pilot plant scale models. Currently the majority of these systems are still in a shakedown mode and have encountered some engineering problems which, although not insurmountable, must be addressed and effectively corrected before the systems can be considered operational.

The purpose of this report is to describe in some detail each of the types of processes which may have application in Montana and to evaluate them relative to the identified marketing situations available in the State. It is not the

intent of this report to identify one process or system as being the best or worst choice. It is recognized that each system has its own special problems and special requirements and that any system being considered will require hand tailoring to fit each situation's requirements.

In any final planning, it should be recognized that the landfill is still part of the scene and probably always will be to some degree; but, in general the present day ethic is the recovery or reuse of as much of the solid waste as is technically possible and economically feasible. This report is devoted to discussion of the technologies that will ultimately satisfy this requirement.

B. SUMMARY OF ALTERNATIVES INVESTIGATED

Through in-depth investigations relative to: (1) the existing solid waste management system in the State of Montana, (2) the identification of potential energy users in the State which may be able to utilize processed solid waste as an energy source, and (3) the evaluation of current solid waste processing and disposal technologies, it was determined that several solid waste disposal and utilization alternatives are potentially applicable in the state. To address these potential alternatives, the report is divided into four major categories: (1) the direct disposal of solid waste, (2) the transfer of solid waste, (3) solid waste processing, and (4) the utilization of energy and material resources in solid waste. The technical requirements and estimated costs of each are summarized in Parts Two through Five.

Basically, the direct disposal of solid waste involves the controlled disposal of refuse on land without creating air, land or water pollution nuisances, or hazards to public health. A properly operated land disposal site is usually referred to as a sanitary landfill. In a properly operated sanitary landfill, engineering techniques are employed to confine the refuse to the smallest practical volume after which it is covered with a four to six inch layer of earth at the conclusion of each day's operation, or at more frequent intervals as may be necessary. Presently, the sanitary landfill is the most extensively used method of solid waste disposal in the United States.

The second alternative analyzed in this report is the use of transfer stations. Although there are many variations in the design of transfer stations, the basic philosophy behind their use is the same; by consolidating waste from smaller vehicles (primary haulers) to larger tractor-trailer units or roll-off containers (secondary haulers), transportation cost can often be decreased. The basic concept of transferring solid waste from a relatively small payload route-collection vehicle to a bulk hauler has been practiced for several decades. Reducing the travel distance of several collection vehicles by replacing them with one large payload vehicle going to a processing plant or ultimate disposal site offers savings. The savings, however, must be sufficient to recover the cost of owning and operating the transfer station and transfer vehicles.

The third basic alternative analyzed involves the processing of solid waste. The primary purpose of processing is to accomplish some level of materials separation and waste preparation such that the product can be utilized either as an energy source or as a soil conditioner. A secondary purpose for processing is to obtain a material which is more homogenous and therefore much easier to transport and/or dispose of. The degree of processing required is dictated by the demand and market for the recoverable materials found in the solid waste stream and by the ultimate use of the processed waste. For this project three degrees of processing were analyzed. They vary from a preliminary processing mode where the solid waste is shredded and the ferous metals removed to a highly sophisticated process where the waste is shredded twice, air classified and the recovery of ferrous, aluminum, other non-metals and glass is achieved utilizing a combination of magnetic separators, trommel screens and other separation equipment. These processes will be discussed in detail in Part Four of this report.

The fourth alternative analyzed involves the actual utilization of processed solid waste. Four utilization alternatives were determined to be applicable in the state and are discussed in this report. These alternatives include: (1) the utilization of processed solid waste as a primary fuel to produce steam for heating and/or cooling purposes, with the option to generate electricity; (2) the utilization of processed solid waste as a supplemental fuel in a suspension-fired boiler to produce steam and/or electricity; (3) the utilization of processed solid waste as a feedstock in a pyrolysis unit to produce a low Btu gas which can be substituted for natural gas; and (4) the utilization of processed solid waste as a soil conditioner. A detailed description, site layout and cost estimate for each of the utilization processes listed above are included in Part Five of this report.

PART TWO

ANALYSIS OF SANITARY LANDFILLS

PART TWO

ANALYSIS OF SANITARY LANDFILLS

A. GENERAL

Until recently the most common method of solid waste disposal in Montana was to deposit the waste in any convenient ravine, gully, or other suitable land feature without regard to daily cover, ground water pollution, rodent control, fire prevention, or other health and environmental problems. Generally speaking, such disposal facilities are referred to as "dumps." For the most part the larger cities in Montana have improved their method of operation and are attempting to operate approved sanitary landfill sites. The majority of the smaller communities are, however, still operating non-approved disposal areas.

Under present Montana solid waste laws and regulations, all disposal sites which receive organic wastes must cover the deposited material at the end of each operating day. The regulations also require that the wastes must be confined to the disposal area. In addition, each facility must be located where the leachate from the wastes can be controlled, especially from percolating into underlying formations which have hydraulic continuity with usable waters.

Today, with ever-increasing disposal costs, efficient sanitary landfilling is essential. A given amount of cover soil can be used to properly cover only a limited amount of solid waste. In a sense, when a parcel of land is purchased for landfilling, it is purchased for the amount of cover soil available within that parcel of land. Consequently, every cubic yard of cover soil is worth a fixed dollar value. It is up to the facility operator to use the cover soil wisely, making maximum use of its ability to cover solid waste. Otherwise, the investment in cover soil yields a poor return in terms of solid waste accommodated at the landfill site for the dollars expended.

There are several factors which must be considered prior to locating a sanitary landfill. Listed below are the fundamental factors which should be analyzed.

1. The site must be located to keep driving time and distance for collection or transfer vehicles to a minimum. A landfill site should be accessible from highways and major arterial streets.

2. The area of land, the cost of purchasing and owning the land, and the capacity of a site must be considered to insure an economical operation.

3. The capacity of a site is dependent upon its area and

possible usable depth. Usable depth depends on available cover material and on the final use plan. A major portion of the cost of a sanitary landfill operation is the movement and placement of earth cover. This material must be suitable in quality and adequate in quantity for a proper and economical operation. Before a final decision is made on a specific site, preliminary soil borings are necessary to give adequate subsurface knowledge of the site and its capacity.

4. Terrain, soil cover, surface drainage, ground water and subsurface conditions should be analyzed to be certain that the site can be developed and used for filling without undue expense and without potential water pollution. Waste material should not be placed in ground which can be flooded from surface drainage or saturated by a high ground water table.

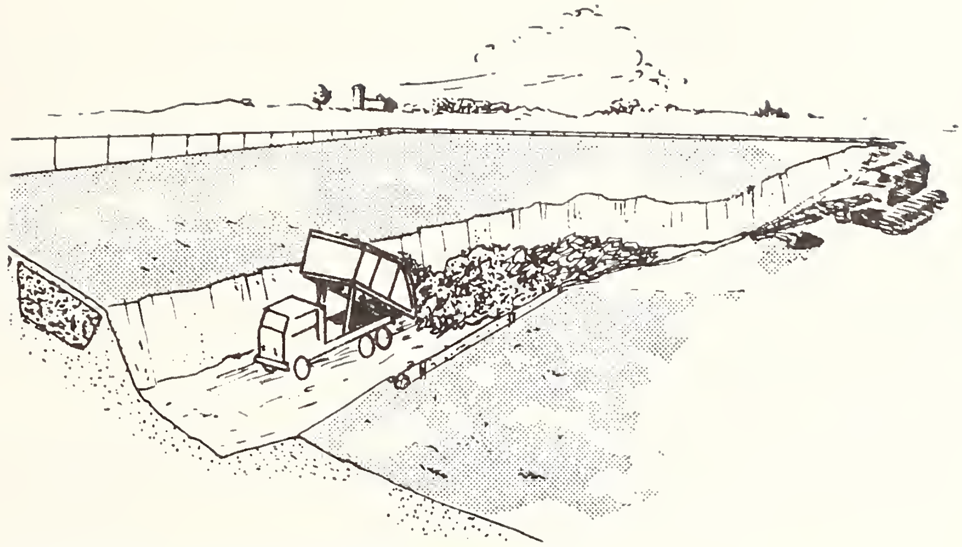
There are a variety of methods for operating a sanitary landfill. The two most prominent methods are the cut and cover, or trench type; and the area-fill method. The trench method is very simple to conceive and operate but is only appropriate where the waste is not to be successively piled to any extent. The area method is more complicated to conceive and to operate but permits the more efficient use of cover material and the filling of waste to greater depths.

In the trench method, trenches are excavated with a front-loader, bulldozer, scraper or dragline and waste is then deposited and a bulldozer or compactor is used to spread or consolidate it. At the end of each operating day, the waste is covered with a 4-6 inch layer of soil. In this method, the earth cover is obtained on-site, either by excavating the trench ahead of the working face or by excavating a trench that is to be filled with waste at a later time. Figure II-1 illustrates this method.

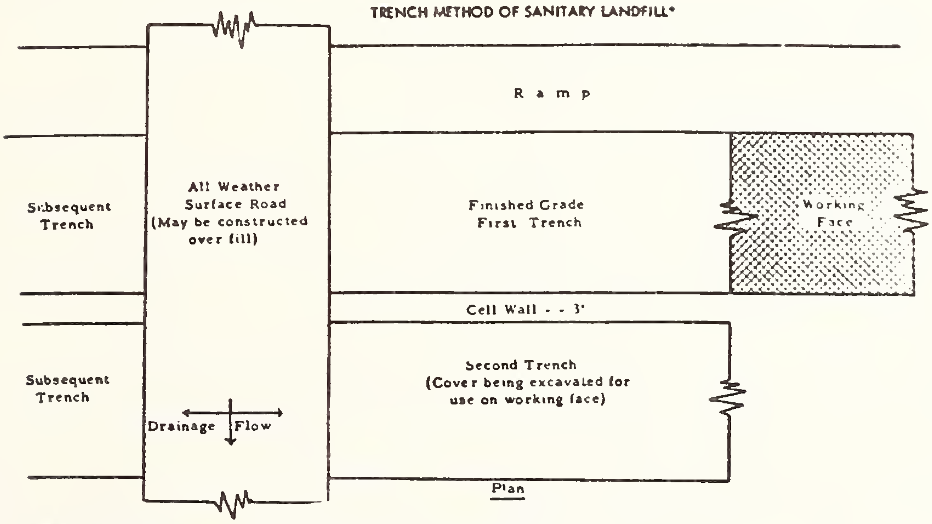
The area method of landfilling differs from the trench method in that minimal site preparation is required. In the area method, cells are constructed in various directions from a given starting point until the entire site is filled. Each cell represents the waste received from one operating day. Cover material is excavated from areas adjacent to the working face of the landfill and is deposited over the previously compacted refuse. Figure II-2 illustrates the area landfill method.

B. APPLICATION IN STATE OF MONTANA

1. General. An analysis of the quantities and concentrations of wastes generated in the state indicates there are presently 245 disposal sites in the state receiving from 2 to 2000 tons per week of solid waste. As stated previously, only a small percentage of these disposal sites are in compliance



TYPICAL ILLUSTRATION

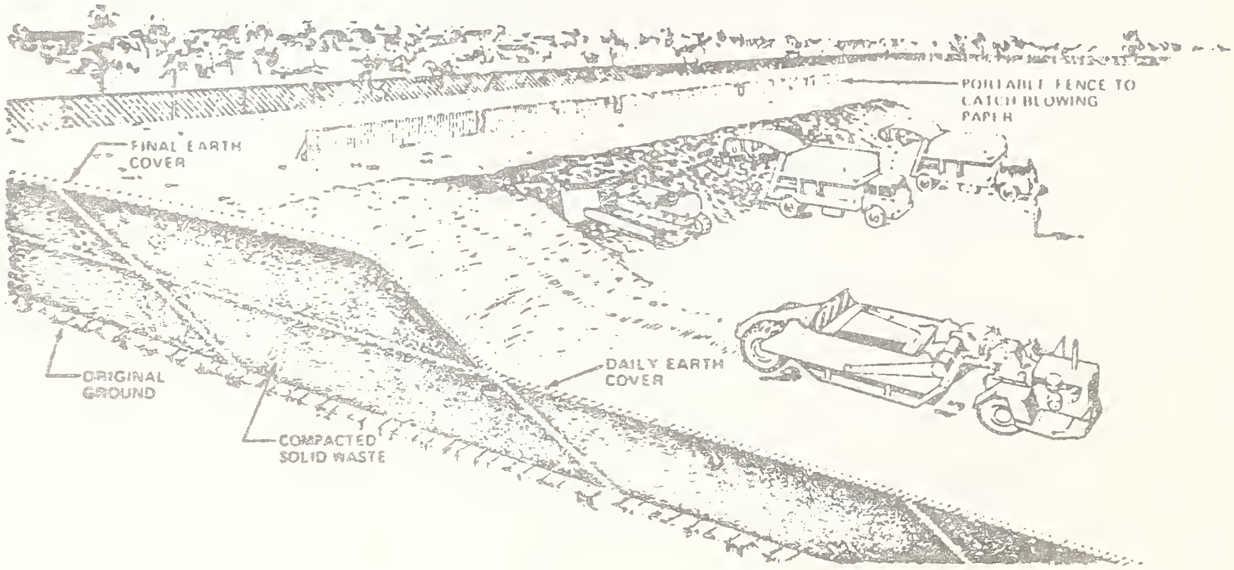


TYPICAL PLAN VIEW

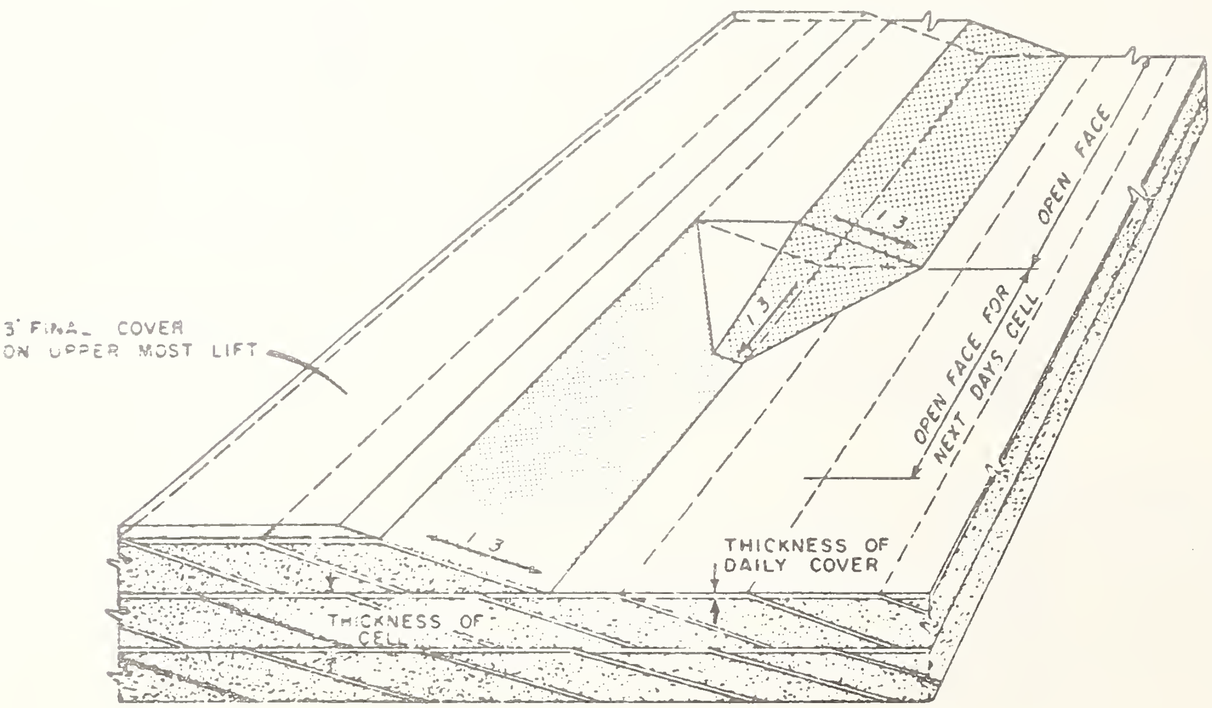
TYPICAL ELEVATION VIEW

SANITARY LANDFILL TRENCH METHOD

FIGURE II - 1



TYPICAL ILLUSTRATION



TYPICAL PLAN VIEW

SANITARY LANDFILL AREA METHOD

FIGURE II - 2

with the state regulations which require that all organic wastes be covered with soil at the end of each operating day. Because the majority of the disposal sites in the state are not covering daily, the costs presently incurred to operate these non-approved sites are substantially lower than if the sites were to be operated properly.

For this project estimated costs to operate state approved sanitary landfills were determined for fifteen various size landfills, ranging from 2 to 2000 tons per week. The reasons for determining the costs for this variety of landfills were: (1) to determine how the disposal cost per ton is affected by the quantity of waste disposed of, and (2) to develop a base disposal cost for comparison with other solid waste processing and utilization alternatives. Included in the following pages is a brief description of the operating criteria required to properly operate various size landfills and the estimated costs associated with each.

2. Procedure and Operating Requirements. For each of the sanitary landfills evaluated, the site, equipment and labor requirements were determined by: (1) interviews with manufacturers who supply sanitary landfill equipment; (2) interviews with personnel presently involved in the operation of landfills throughout the state; (3) on-site inspections of properly operated landfills throughout the country, and (4) a review of the operational criteria recommended by the State Solid Waste Management Bureau. Included in Appendix A is a listing of the criteria required or recommended by the State Solid Waste Management Bureau and also a detailed breakdown of the capital and operating costs for the various size landfills analyzed.

In determining the landfill design criteria, an important item is the hours of operation necessary to handle the quantity of waste expected. Often, the limiting factor is not how long the equipment must run to properly handle that solid waste, but rather how long the facility should be open to be of convenience to the people of the community. For this project it was assumed that each landfill would be open a minimum of two days per week.

For properly operated facilities, a major expense is the capital and operating cost of the equipment. Through a detailed analysis it was determined that in most instances it it more economical to purchase either a new or used piece of equipment than it is to rent or contract. It should be noted, however, that the decision to rent and/or contract equipment versus purchasing new or used equipment will depend upon the local conditions. For this project it was assumed that all equipment utilized at a sanitary landfill would be purchased. For landfills receiving greater than 350 tons per week of waste it was assumed that a dozer and/or a compactor would be required. Appendix A shows the types of equipment which would be necessary to properly operate the various size landfills.

A second major expense is labor. Through the State Solid Waste Management Bureau's and the Consultant's experience, it was determined that for very small landfill operations, the only labor required would be for equipment operation to cover the waste at the end of each day the landfill is open. For larger landfills it was determined that a gate keeper would be required to record quantities and supervise dumping. Appendix A depicts the estimated labor requirements for the various size landfills.

3. Cost Estimates. Based on the capital and operational criteria discussed in this chapter and in Appendix A, capital and annual costs were determined to operate landfills receiving 2 to 2000 tons per week of waste. A breakdown of the capital and annual costs of the various size landfills are summarized in Tables II-1 through II-3. The annual operating costs are shown in Figures II-3 through II-5. The capital costs are based on June, 1976 construction, equipment and material costs. To determine an annualized cost of the capital investment, all buildings, sitework and accessories were amortized over a 15 year period and all capital equipment costs were amortized over the anticipated life of the equipment. The costs do not, however, include the price of land since specific sites have not been selected.

For landfills receiving 2 to 50 tons per week of waste, costs were determined for operating each site for two, three, four and five days per week. As discussed previously, state regulations require that all incoming waste must be covered with soil the same day. Therefore, as the number of days a landfill is open increases, the cost per ton for disposal also increases. Tables II-1 and II-2 summarize the capital and annual costs to operate landfills varying in size from 2-50 tons per week. As shown, the capital investiment for each landfill varies from $50,000 - $84,500. The increased capital investment for the larger landfills is a result of the need to purchase more expensive machinery dur to the increased quantity of waste handled and the reliability required.

TABLE II-1

SANITARY LANDFILL CAPITAL COST SUMMARY
(2-50 Tons Per Week)

Facility Size (TPW)	2-8	10	30	50
Population Served	200-800	1000	2400	4000
Item	Capital Cost			
Utilities, Roads, etc.	$13,500	$13,500	$13,500	$13,500
Equipment	30,000	40,000	50,000	60,000
Contingencies	6,500	8,000	9,500	11,000
Total	$50,000	$61,500	$73,000	$84,500

TABLE II-2

SANITARY LANDFILL ANNUAL COST SUMMARY
(2-50 TPW)

Tons per Week	2 TPW				4 TPW				6 TPW			
Days open for Operation	2	3	4	5	2	3	4	5	2	3	4	5
Item												
Equipment Maint. Operation & Depr.	$ 3,600	$ 4,400	$ 5,100	$ 6,200	$ 3,600	$ 4,400	$ 5,100	$ 6,200	$ 3,600	$ 4,400	$ 5,100	$ 6,200
Site Maint & Operation	$ 650	$ 750	$ 850	$ 960	$ 750	$ 860	$ 970	$ 1,100	$ 850	$ 970	$ 1,100	$ 1,230
Labor (including benefits @ 30%)	$ 2,500	$ 3,700	$ 4,900	$ 6,100	$ 2,500	$ 3,700	$ 4,900	$ 6,100	$ 2,500	$ 3,700	$ 4,900	$ 6,100
Amortization of Capital 15 yr. @ 7.5%	$ 5,660	$ 5,660	$ 5,660	$ 5,660	$ 5,660	$ 5,660	$ 5,660	$ 5,660	$ 5,660	$ 5,600	$ 5,600	$ 5,600
Total Annual Cost	$12,410	$14,510	$16,510	$18,920	$12,510	$14,620	$16,630	$19,060	$12,610	$14,730	$16,760	$19,190
Cost Per Ton	$124.10	$145.10	$165.10	$189.20	$ 62.55	$ 73.30	$ 83.15	$ 95.30	$ 42.03	$ 49.10	$ 55.87	$ 63.96

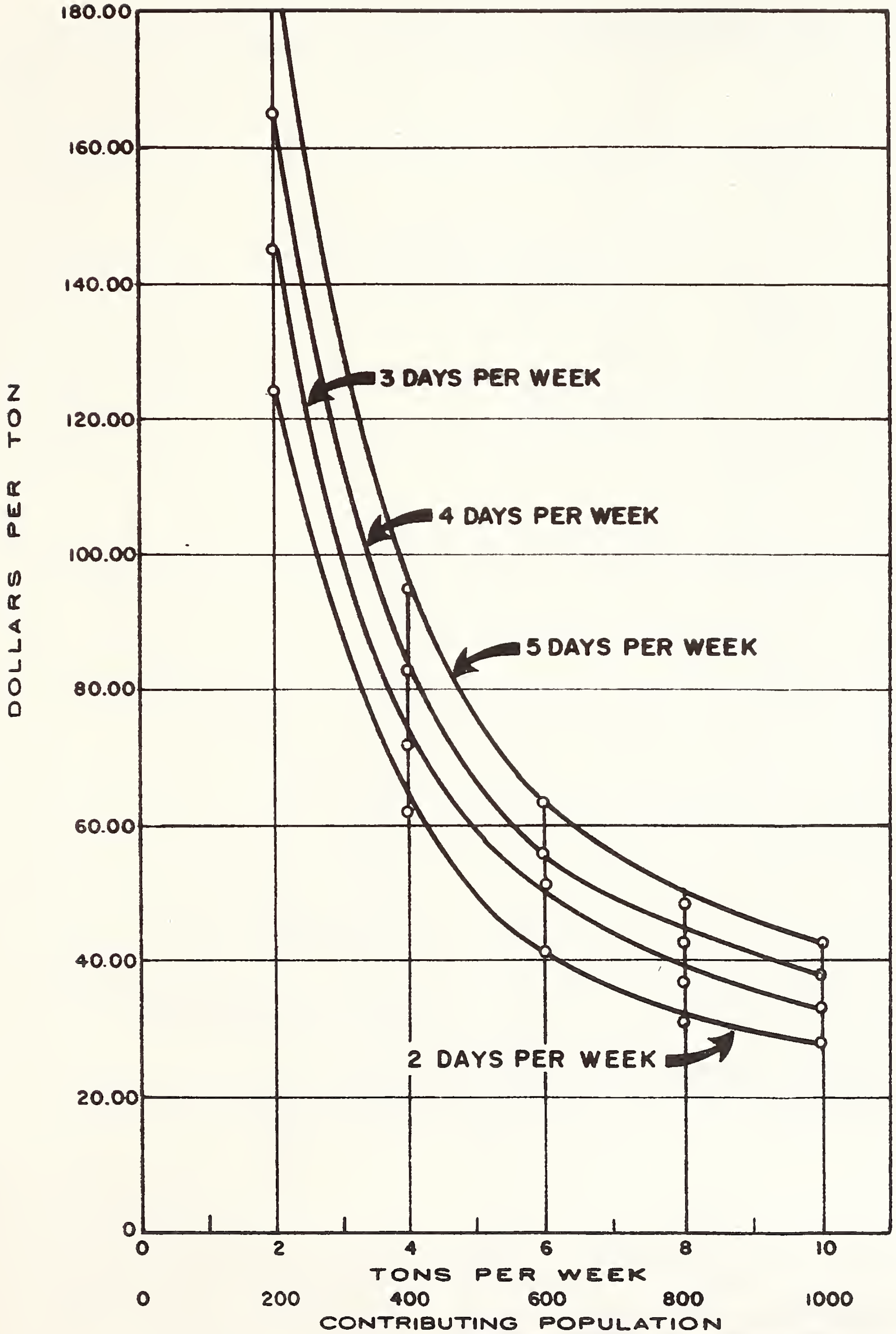
Tons per Week	10 TPW				30 TPW				50 TPW			
Days open for Operation	2	3	4	5	2	3	4	5	2	3	4	5
Item												
Equipment Maint. Operation & Depr.	$ 3,600	$ 5,100	$ 5,800	$ 6,900	$ 4,000	$ 5,800	$ 6,400	$ 7,500	$ 4,400	$ 6,700	$ 7,500	$ 8,200
Site Maint & Operation	$ 1,450	$ 1,500	$ 1,650	$ 1,800	$ 3,300	$ 3,550	$ 4,400	$ 4,950	$ 5,500	$ 5,950	$ 6,600	$ 7,150
Labor (including benefits @ 30%)	$ 2,500	$ 3,700	$ 4,900	$ 6,100	$ 3,100	$ 3,700	$ 4,900	$ 6,100	$ 3,700	$ 3,700	$ 4,900	$ 6,100
Amortization of Capital 15 yr. @ 7.5%	$ 6,970	$ 6,970	$ 6,970	$ 6,970	$ 8,270	$ 8,270	$ 8,270	$ 8,270	$ 9,570	$ 9,570	$ 9,570	$ 9,570
Total Annual Cost	$14,520	$17,270	$19,320	$21,770	$18,670	$21,320	$23,970	$26,820	$23,170	$25,920	$26,570	$31,020
Cost per Ton	$ 29.04	$ 34.54	$ 38.64	$ 43.54	$ 12.44	$ 14.21	$ 15.98	$ 17.88	$ 9.27	$ 10.21	$ 10.63	$ 12.41

TABLE II-3

SANITARY LANDFILL COST SUMMARY

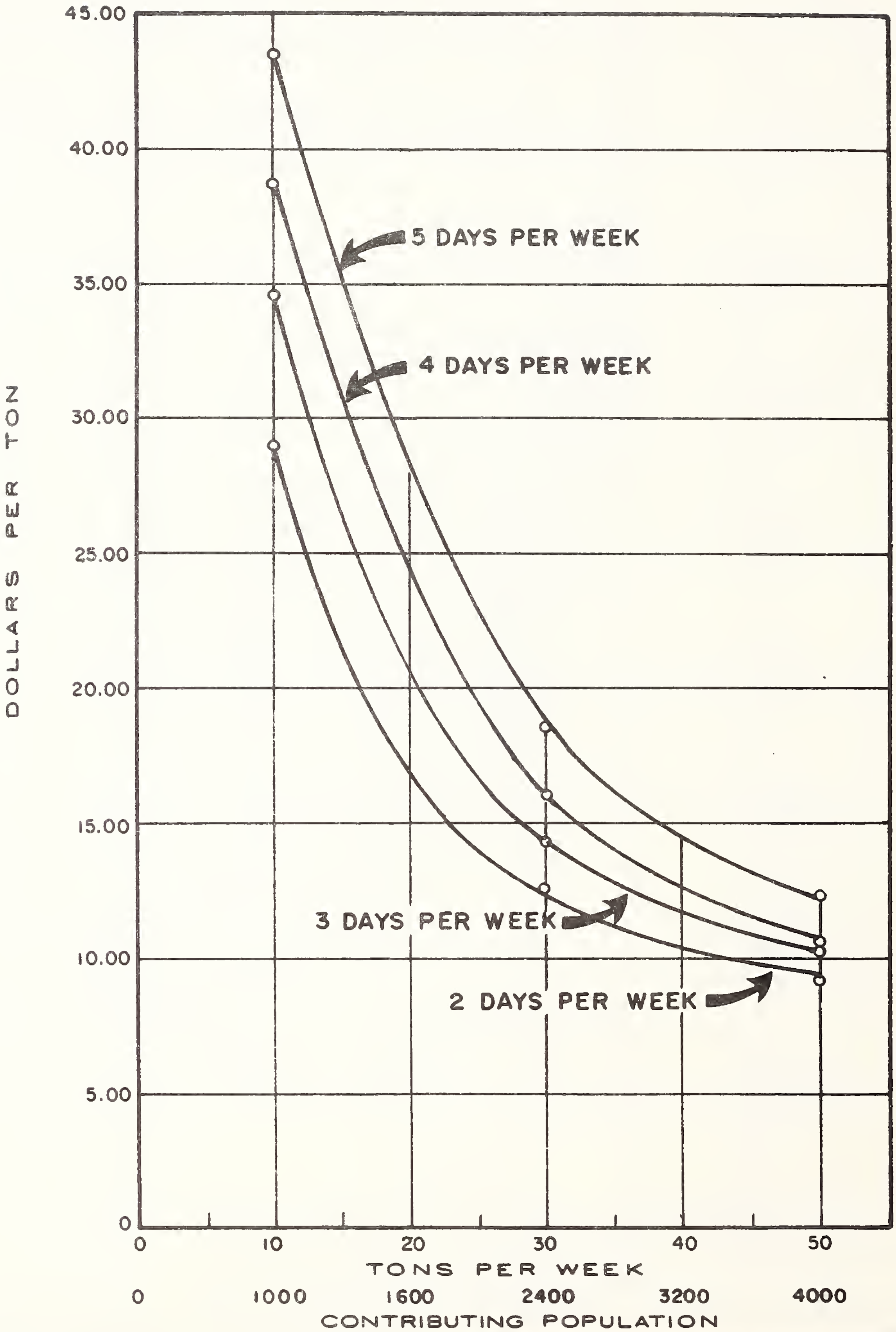
(100-2000 tons per week)

Facility Size TPW	100	200	350	500	750	1,000	1,500	2,000
Estimated Population Served	6,000	10,000	17,500	25,000	37,500	50,000	75,000	100,000
Capital Costs								
Item								
Utilities, Roads, etc.	$ 9,000	$9,800	$16,600	$19,400	$20,400	$21,300	$23,400	$23,400
Buildings	9,000	9,000	32,000	35,000	35,000	39,000	51,000	51,000
Equipment	60,000	60,000	95,000	145,000	182,000	257,000	257,000	257,000
Contingencies, Legal & Engr. @ 15%	11,700	11,800	21,500	29,900	35,600	47,600	49,700	49,700
TOTAL	$ 89,700	$90,600	$165,100	$229,300	$273,000	$364,900	$381,100	$381,100
Annual Cost								
Equipment Maint, Operation & Depr.	$ 19,400	$24,900	$33,100	$33,900	$47,600	$62,000	$116,700	$133,700
Site Maintenance & Operation	700	1,000	1,000	1,000	1,200	1,400	1,500	1,500
Labor (Inc. Benefits @30%)	7,700	9,300	17,200	28,300	39,300	49,400	57,400	65,500
Amortization of Capital	10,200	10,300	18,700	26,000	30,900	41,300	43,200	43,200
TOTAL ANNUAL COST	$ 38,000	$45,500	$70,000	$89,200	$119,000	$154,100	$218,800	$243,900
COST PER TON	$ 7.60	$4.55	$4.00	$3.56	$3.17	$3.08	$2.92	$2.44



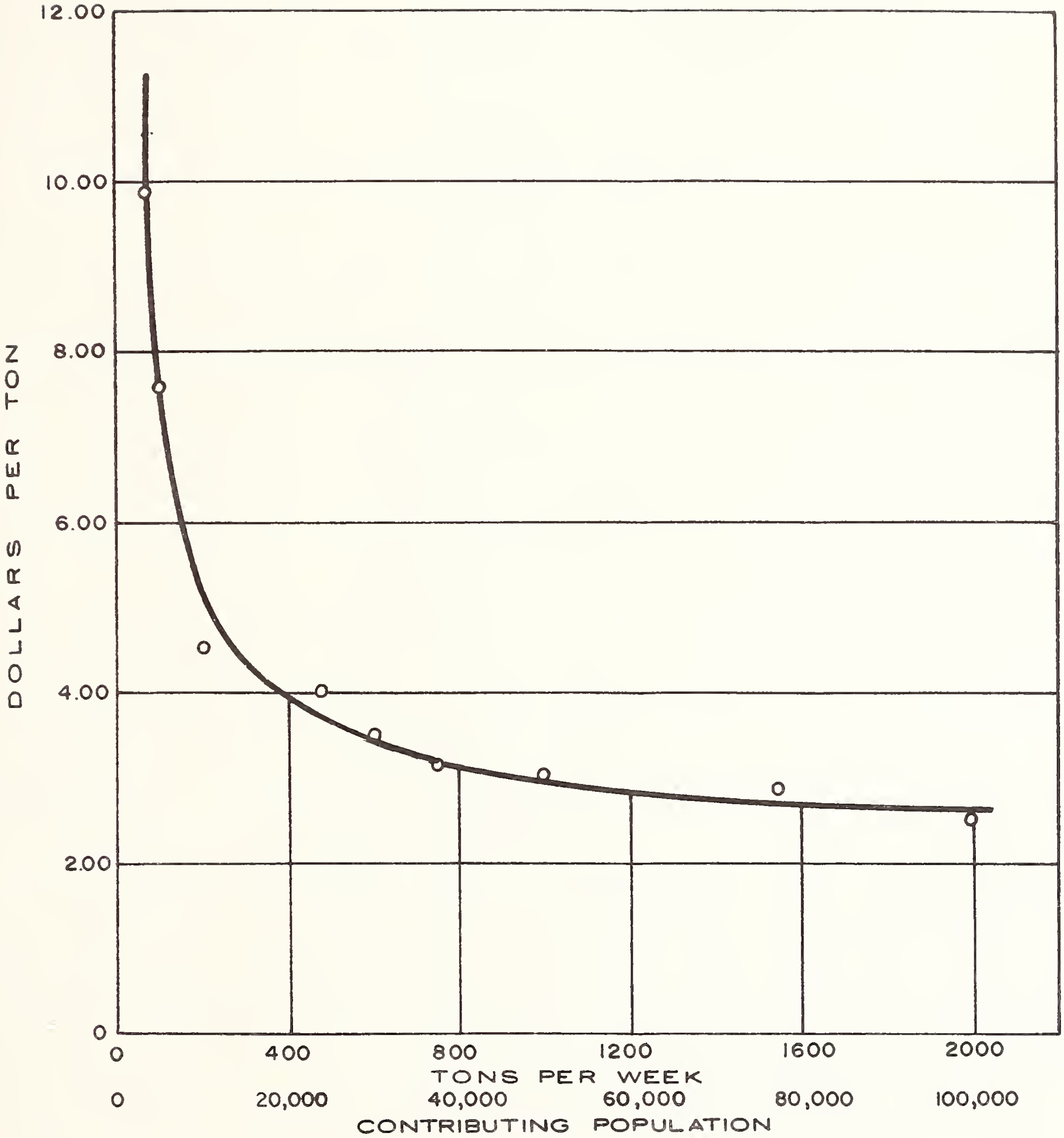
SANITARY LANDFILL COSTS
2 - 10 TONS PER WEEK

FIGURE II-3



SANITARY LANDFILL COSTS
10 - 50 TONS PER WEEK

FIGURE II - 4



SANITARY LANDFILL COSTS
50 - 2000 TONS PER WEEK

FIGURE II - 5

A review of Figures II-3 and II-4 depicts the wide variance in the disposal cost per ton for the landfills ranging in size from 2-50 tons per week. As illustrated, the disposal cost varies from approximately $189 per ton for a landfill properly operated five days per week serving a population of 200 to approximately $12 per ton for a landfill properly operated five days per week serving a population of 4,000. This indicates very well the fact that the disposal cost per ton decreases substantially as the quantity of waste landfilled increases. Thus, it is advantageous for small communities to consolidate their respective landfills into larger operations.

It is also interesting to note that the disposal cost per ton increases substantially as the degree of service increases for landfills receiving small quantities of waste. For example the cost to operate a landfill serving a population of 400 varies from approximately $90 to $63 per ton depending upon the number of days the landfill is open. Figure II-4 also shows that the degree of service becomes a lesser factor as the quantity of waste increases. For example, the disposal cost for a city with a population of 4,000 varies only from approximately $9 to $12 per ton depending upon the number of days the landfill is open.

Through an analysis of existing disposal practices and requirements in the state, it was determined applicable that all landfills serving populations of 4,000 or greater should be open a minimum of 5 days per week to provide sufficient service to the contributing population. Based on this criteria, the capital and annual costs were determined for several size landfills ranging in size from 100 to 2,000 tons per week. These capital and annual costs are summarized in Table II-3. As the table indicates, the capital costs vary from approximately $90,000 to $381,000 for landfills ranging from 100 to 2,000 tons per week. Figure II-5 further summarizes the cost per ton to operate the various size landfills. As shown, the cost per ton to operate a 2,000 ton per week landfill is approximately $2.44 per ton. This represents the waste generated from a population of approximately 100,000. This compares to a cost per ton of $7.60 for a landfill which would serve a population of approximately 7,000. This again illustrates the savings that can be realized by consolidating smaller landfills into larger landfills.

PART THREE

ANALYSIS OF TRANSFER STATIONS

PART THREE

ANALYSIS OF TRANSFER STATIONS

A. GENERAL

The primary function of a solid waste transfer station is to reduce the total cost of hauling from the point of collection to the point of disposal. Transfer is usually accomplished by consolidating refuse from several individual loads into one large load and then transporting that waste in a more efficient vehicle.

Transfer stations fall into a wide range of system sizes and complexity. A brief description of the basic types of transfer systems is included in the following text. Systems discussed range in size from 4 to 8 cubic yard non-compacted containers, to large transfer stations with a pit dump, dozers and various arrangements of stationary compactors.

1. "Green Box" System. One concept in rural collection and transfer is the "Green Box" System. This system basically consists of placing 4 to 8 cubic yard containers in strategic locations throughout a rural area. The boxes are usually collected 1 to 3 times per week depending upon the location and contributing population. By using the "Green Box" system, promiscuous dumping, littering, and unsanitary conditions, prevalent in many rural areas, can be alleviated.

2. Roll Off Containers (Non Compacted). This is essentially the same as the "Green Box" system described above except that fewer, but larger, collection points are used. The design of such a facility requires an elevation differential of at least ten feet. The roll-off container can range in size from 20 to 50 cubic yards. The transfer is made by driving incoming collection vehicles up a ramp, and discharging the waste into the container. A special vehicle is then used to pick up the container and transfer it to a disposal or resource recovery facility.

3. Stationary Compactors. With this type of transfer station the refuse is densified by use of a stationary compactor. Compaction can be done into a roll-off container or a transfer trailer. The compaction ratio of material within the secondary haul vehicle may be as high as three to one. There are numerous methods by which refuse received from incoming vehicles can be transferred to the compactor and thus the secondary haul vehicle. For transfer stations of 150 tons per week and less, the compactor will receive the waste by dumping incoming vehicles into a hopper positioned directly over the compaction chamber. For greater refuse transfer rates, where the number of incoming vehicles dictates the need for more than one stall due to queing problems, a floor or pit dump, or a push pit, will be required. For the floor

or pit dump situations a front loader will push the refuse into the compactor's hopper. Another means of receiving waste and loading the compactor is by utilizing a push pit. This concept uses a long pit equipped with a hydraulic ram which when activated pushes the refuse to the compactor charging hopper located at one end of the pit. Once the compression zone of the compactor has been charged with refuse, a compacting ram is activated which forces the material into a roll-off container, or a transfer trailer.

The advantages of the stationary compactor transfer system include: (1) maximum payloads can be obtained; (2) unloading of the trailers is very fast and efficient; (3) the enclosed nature of the trailer does not require that canvas or metal tops be handled with each loading and unloading; (4) the compactor can handle nearly all bulky material that can be placed in the hopper because of the large hydraulic force available.

The disadvantages of the system are (1) should the compactor fail, there is no other way of loading the trailer; (2) the initial cost of the trailers may be more than open-top types and usually they require more maintenance; (3) if the majority of incoming waste is precompacted in collection trucks, the heavier enclosed trailer offers little advantage as maximum payloads can be achieved in lighter open top trailers with top tamping; (4) a trailer must be in place to utilize the system.

4. <u>Pit Dump Transfer Stations.</u> In this type facility incoming refuse is received in a large open pit in which a dozer(s) mangles, compacts, and ultimately moves the material to one end of the pit into open top, noncompacted transfer vehicles. This type of facility is best suited for large high-volume applications. In this type of transfer station, waste is dumped from the collection truck directly into a storage pit. The pit offers the advantage of providing storage as part of the operation. A crawler tractor, or dozer, moves the waste to open top trailers. Fixed-base backhoes may be used to assist in distributing the load.

The advantages of this system are as follows: (1) a convenient and efficient storage area is available that does not clutter the unloading area; (2) uncompacted material is crushed in the pit making maximum payloads obtainable without further processing; (3) the open-top transfer trailers are lighter and capable of carrying larger payloads than the enclosed compactor trailers with their heavy reinforced steel bodies and hydraulic equipment; (4) the open-top trailers are usually less expensive initially and require less maintenance than the enclosed compactor trailers; (5) large volumes of waste can be handled very quickly and many incoming vehicles can be unloaded simultaneously; (6) drive-through loading for transfer vehicles can easily be incorporated into the design.

The compaction pit system has the following disadvantages: (1) considerable capital investment is required to construct the compaction pit and to purchase the crawler tractor; (2) difficulty in obtaining a full "legal limit" payload.

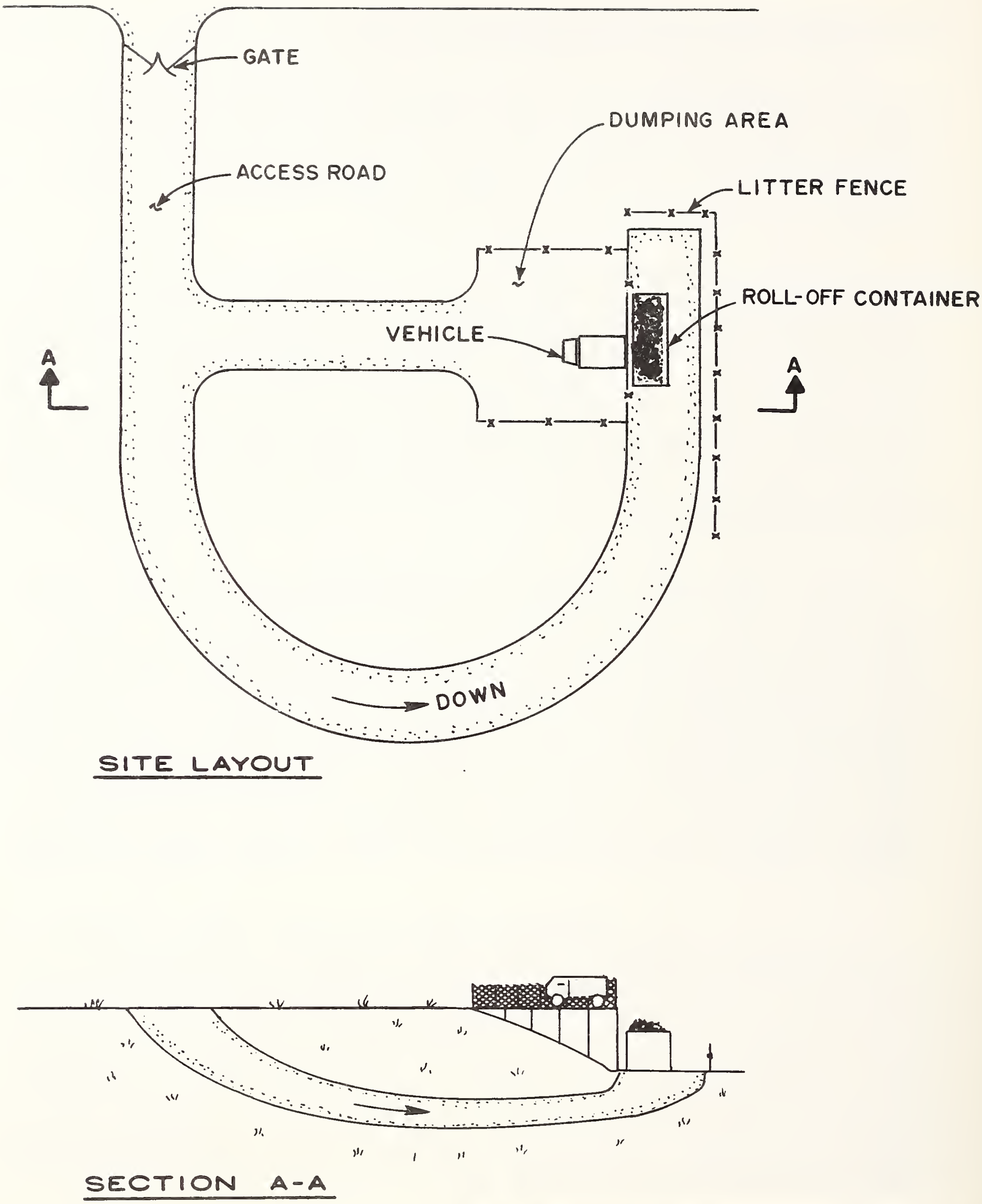
B. APPLICATION IN STATE OF MONTANA

1. General. An analysis of the quantities and concentrations of solid waste generated in the state indicates that transfer stations are a definite viable alternative for solid waste disposal. Because the concentrations of waste vary considerably throughout the state, it was determined necessary to develop layouts and costs for several various types and sizes of transfer stations for this project.

For this project three basic types of transfer stations were evaluated. The transfer stations vary from a simple non-compacted roll-off container system to larger complex stations whereby waste is deposited into a pit and then by use of hydraulic rams and a stationary compactor unit or by tracked vehicles the waste is loaded into large transfer trailers. The latter facilities are utilized primarily when large quantities of waste are handled whereby the container system is used primarily for small towns and rural areas. Included in the following pages is a brief description of the operating requirements of each type transfer station and the situation in which each station has the most applicability.

2. Description of Types of Transfer Stations. For each of the various types and sizes of transfer stations analyzed, the necessary land, site work, utilities, buildings and equipment were determined. These requirements were determined from several sources of information. They include: (1) interviews with manufacturers who supply transfer vehicles and equipment, (2) interviews with personnel presently involved in the operation of transfer stations, and (3) on-site inspections of several transfer stations presently operating in the Pacific Northwest. Included in Appendix B is a listing of the capital and operational criteria and a detailed breakdown of the capital and operating costs for the vsrious size and type transfer stations analyzed. Listed below is a brief summary of the various type transfer stations which were analyzed:

a. Non-compacted roll-off container. This type transfer station is utilized primarily in areas where there is no door to door collection service. The roll-off containers are placed in strategically located areas whereby citizens haul their wastes to the site and deposit the wastes into the container. The containers are then picked up periodically by a specially equipped vehicle and transported to a disposal site. This type of facility does not require any mechanical equipment other than the vehicle necessary to pick up the container. A layout of this type transfer station is shown in Figure III-1. The cost for this type transfer station has been estimated and is summarized in Table III-1.



NON-COMPACTED ROLL-OFF TRANSFER STATION

FIGURE III - 1

TABLE III-1

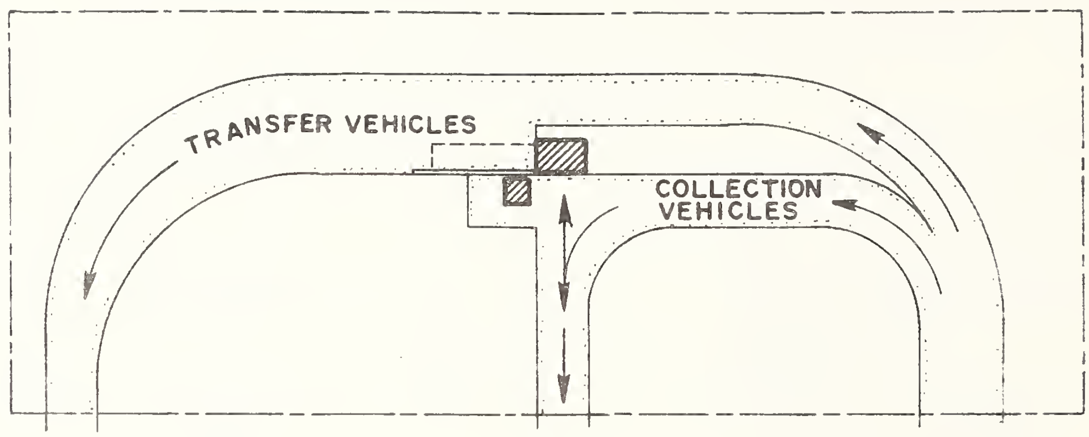
NON-COMPACTED ROLL-OFF TRANSFER STATION

Capital Costs

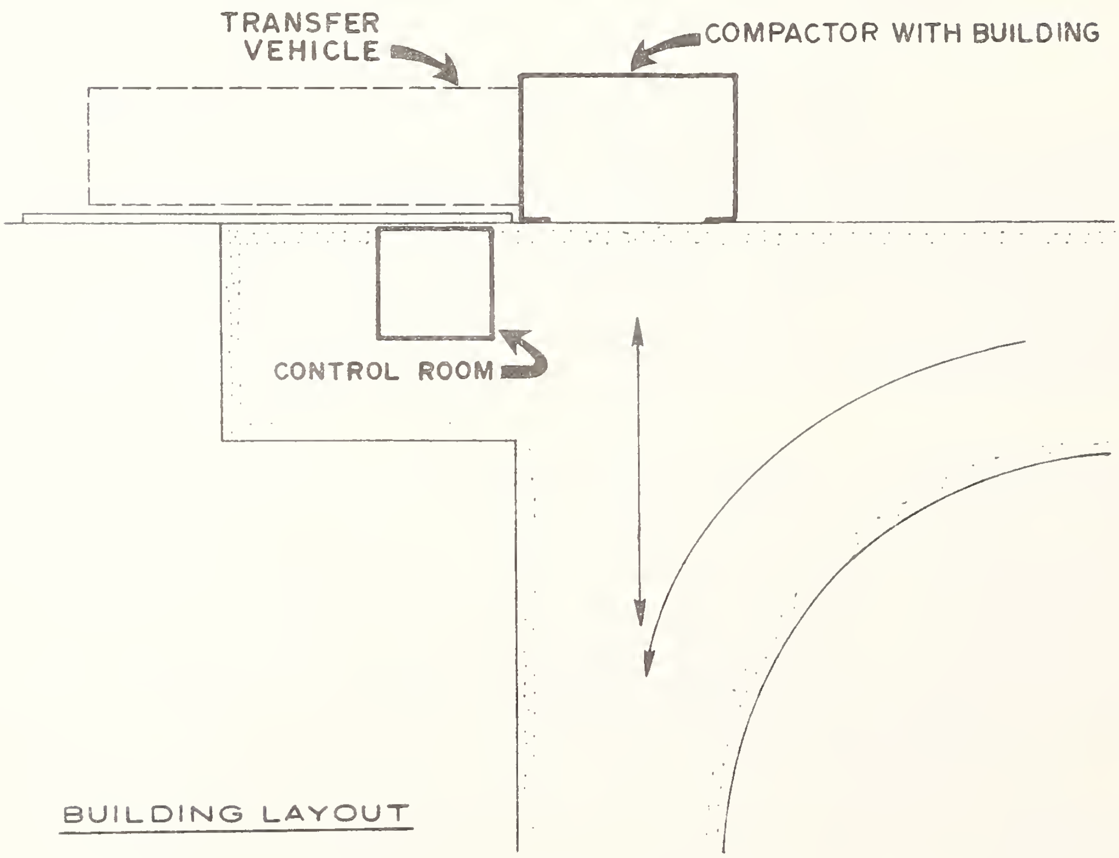
Item	Cost
Sitework	
Ramp	$ 2,000
Grading	1,500
Retaining Wall	3,000
Concrete Slab	4,000
Container (40 cubic yard)	4,500
Contingencies	2,000
Total	$17,000

b. Simple Compacted. The second type of transfer station analyzed was a facility which utilizes a stationary compactor to compact waste into either a roll-off container or a 65 cubic yard transfer tractor. A major advantage of this type station over the non-compacted roll-off type station is the fact that large collection vehicles can deposit waste at this station where the non-compacted station is limited to self-haulers. A second advantage of compacting the waste is to achieve larger quantities of waste hauled per transfer vehicle trip.

Basically the simple compacted station includes a charging hopper, a stationary compactor and a transfer vehicle. Because of the severe climate in Montana, it is also recommended that the charging hopper be enclosed with a metal building to prevent moisture from entering the charging hopper and compactor equipment controls. Depending upon the location of the facility, it may be advantageous to also include a small building over the tipping area. This enclosure prevents the possibility of blowing paper and also adds to the comfort of the individual(s) depositing waste at the station during inclement weather. The site work required at this type station is minimal and includes the preparation of roads, installation of a retaining wall between the tipping level and the transfer level and general landscaping. Layouts of this type station are shown in Figures III-2 and III-3. The capital costs for the various stations illustrated were estimated and are summarized in Table III-2.



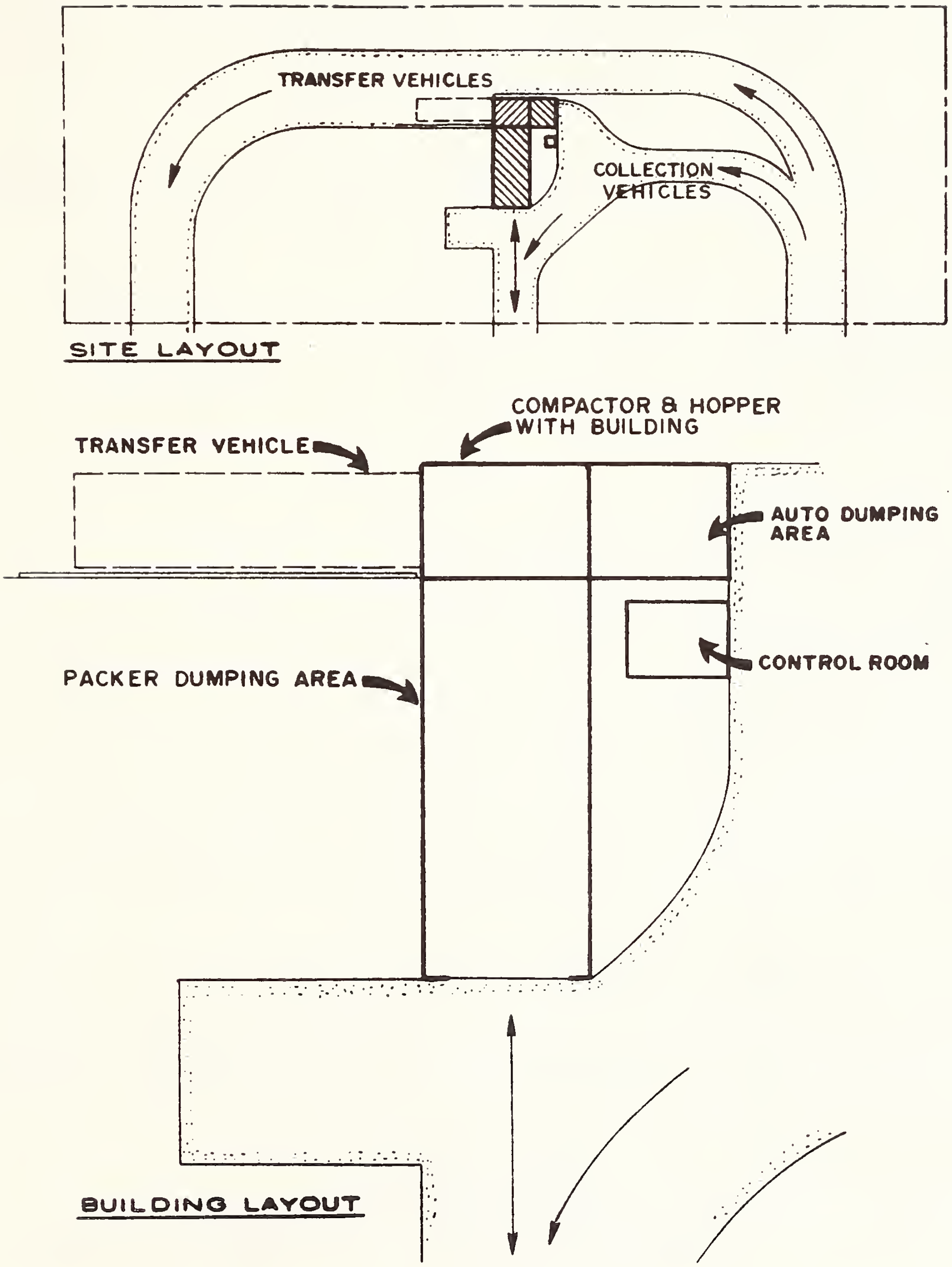
SITE LAYOUT



BUILDING LAYOUT

SIMPLE COMPACTED TRANSFER STATION

FIGURE III - 2



ENCLOSED COMPACTED TRANSFER STATION

FIGURE III - 3

TABLE III-2

SIMPLE COMPACTED TRANSFER STATION

Capital Costs

Item	Cost: Simple Compacted	Cost: Enclosed Compacted
Site Work	$18,100	$18,100
Buildings	9,100	24,100
Equipment	50,000	50,000
Contingencies	11,600	13,800
Total	$88,800	$106,000

c. Push Pit. The third basic type of transfer stations analyzed was a push pit compactor type station. The advantage of push pit type station over the simple compactor station is the increased degree of service the push pit provides. By utilizing a push pit as many as four vehicles can dump solid waste simultaneously. With a simple compacted station only one vehicle can dump at a time. In a push pit arrangement the waste is initially deposited in a large pit. As the pit becomes full a hydraulic ram pushes the waste to one end of the pit where a stationary compactor is located. The stationary compactor then forces the waste into a large transfer trailer. If additional unloading spaces or additional capacity is required, two push pit compactor arrangements can be installed back to back. This not only doubles the capacity of the station but also gives the station back up capabilities.

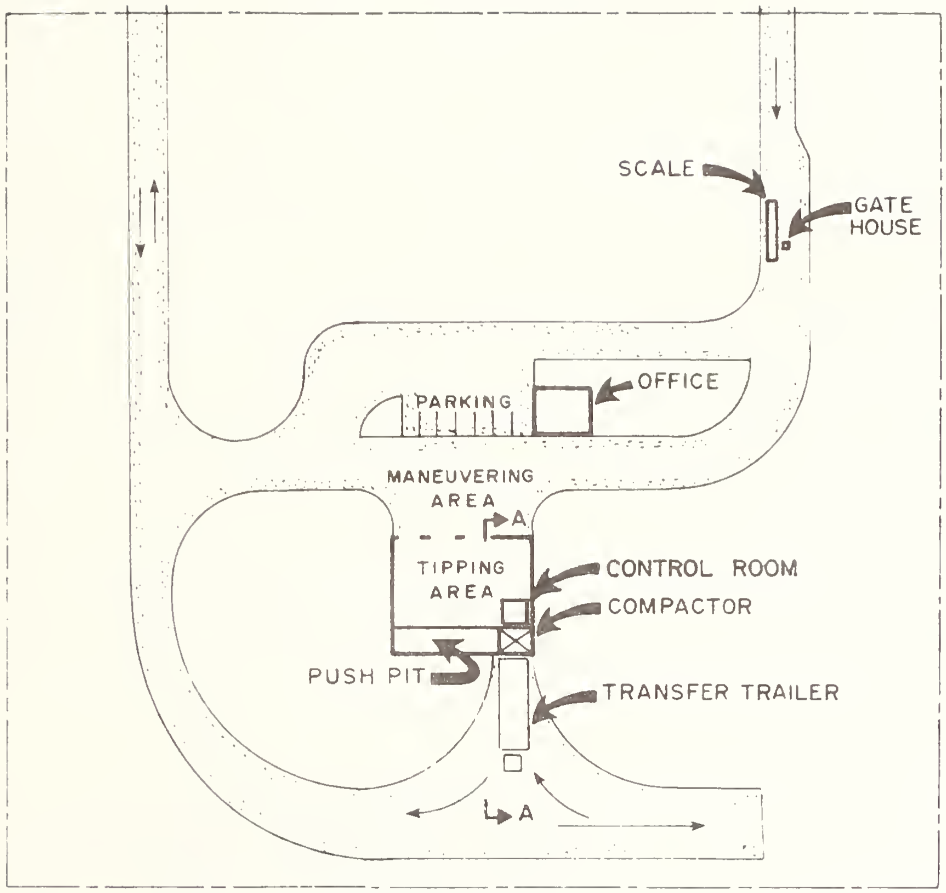
Figures III-4 and III-5 illustrate layouts of single and double push pit transfer stations. As the figures show, all dumping is accomplished in an enclosed building to alleviate blowing paper and increase comfort and aesthetics. The capital costs for a single and double push pit transfer station are summarized in Table III-3.

TABLE III-3

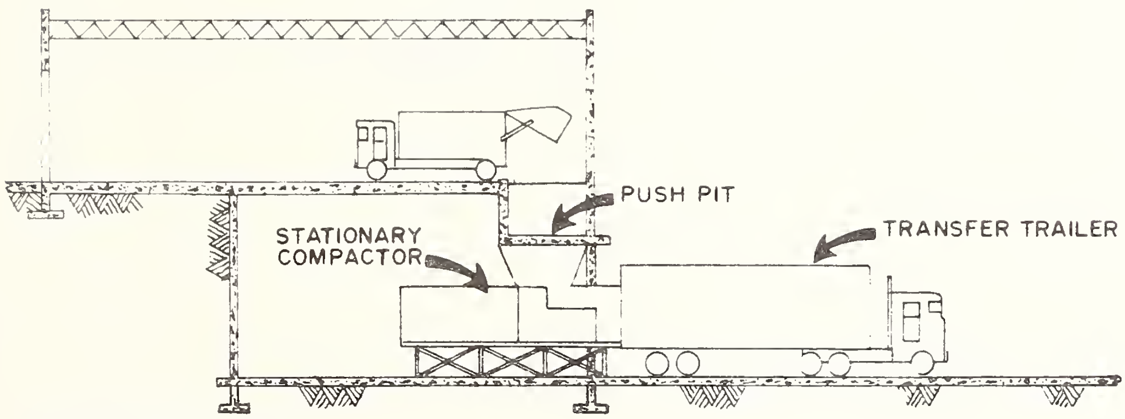
PUSH PIT TRANSFER STATION

Capital Costs

Item	Costs: Single	Costs: Double
Site Work	$ 23,500	$ 40,700
Building	86,100	168,600
Equipment	100,000	149,500
Contingencies	31,400	53,800
Total	$241,000	$412,600



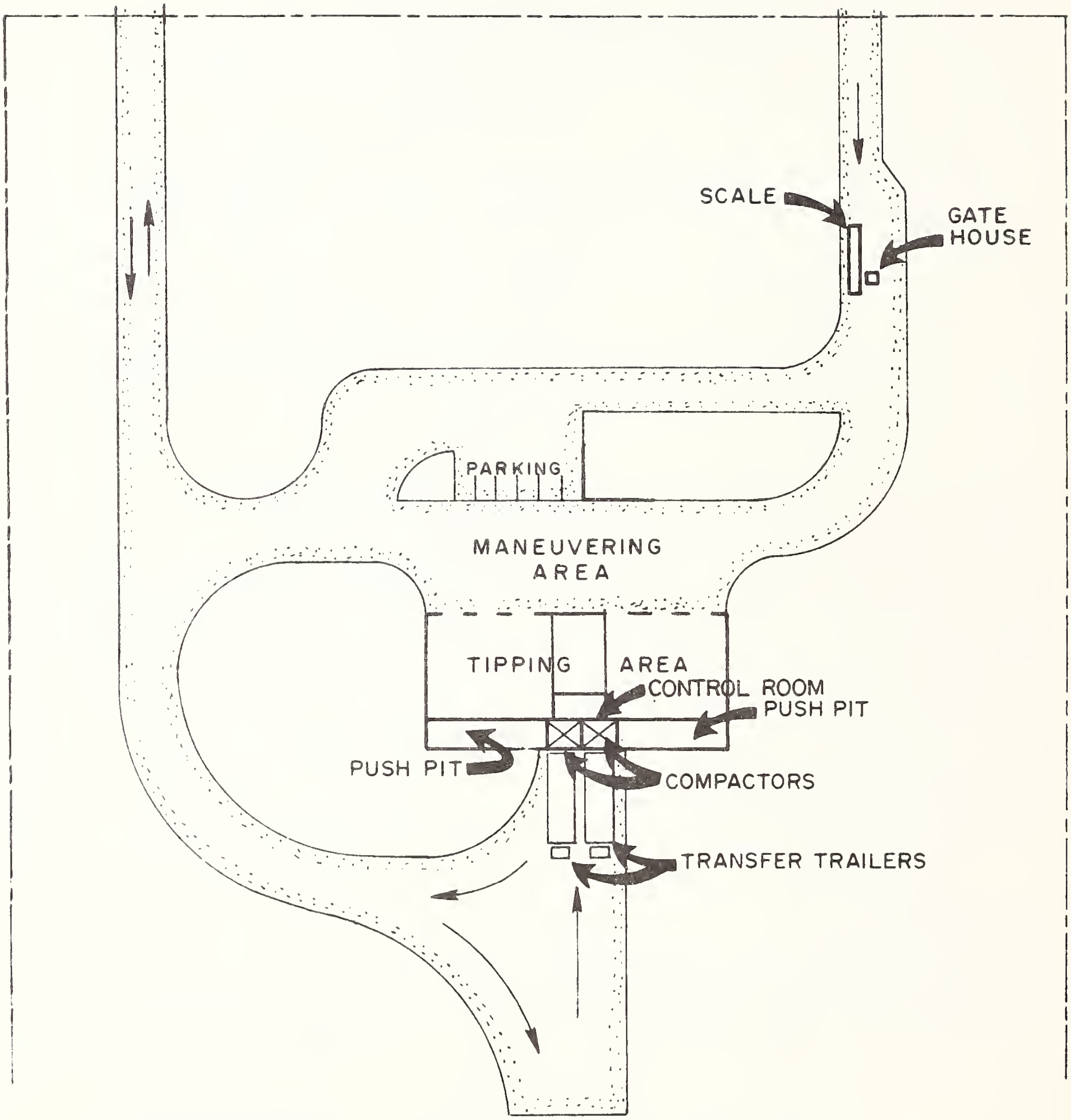
SITE LAYOUT



SECTION A - A

SINGLE PUSH PIT TRANSFER STATION

FIGURE III - 4



SITE LAYOUT

DOUBLE PUSH PIT TRANSFER STATION

FIGURE III – 5

3. Application and Cost Estimates. After reviewing the degree of service each type transfer station could provide, it was determined which type transfer station would be most applicable for a variance of quantities of solid waste generated. Because each area wide solid waste disposal situation in the state is unique, however, no firm rule on which type of transfer should be utilized for a certain contributing population can be set. In actuality, the local situation and economics will dictate the need for a transfer station and also the type of station which would most effectively serve the contributing population.

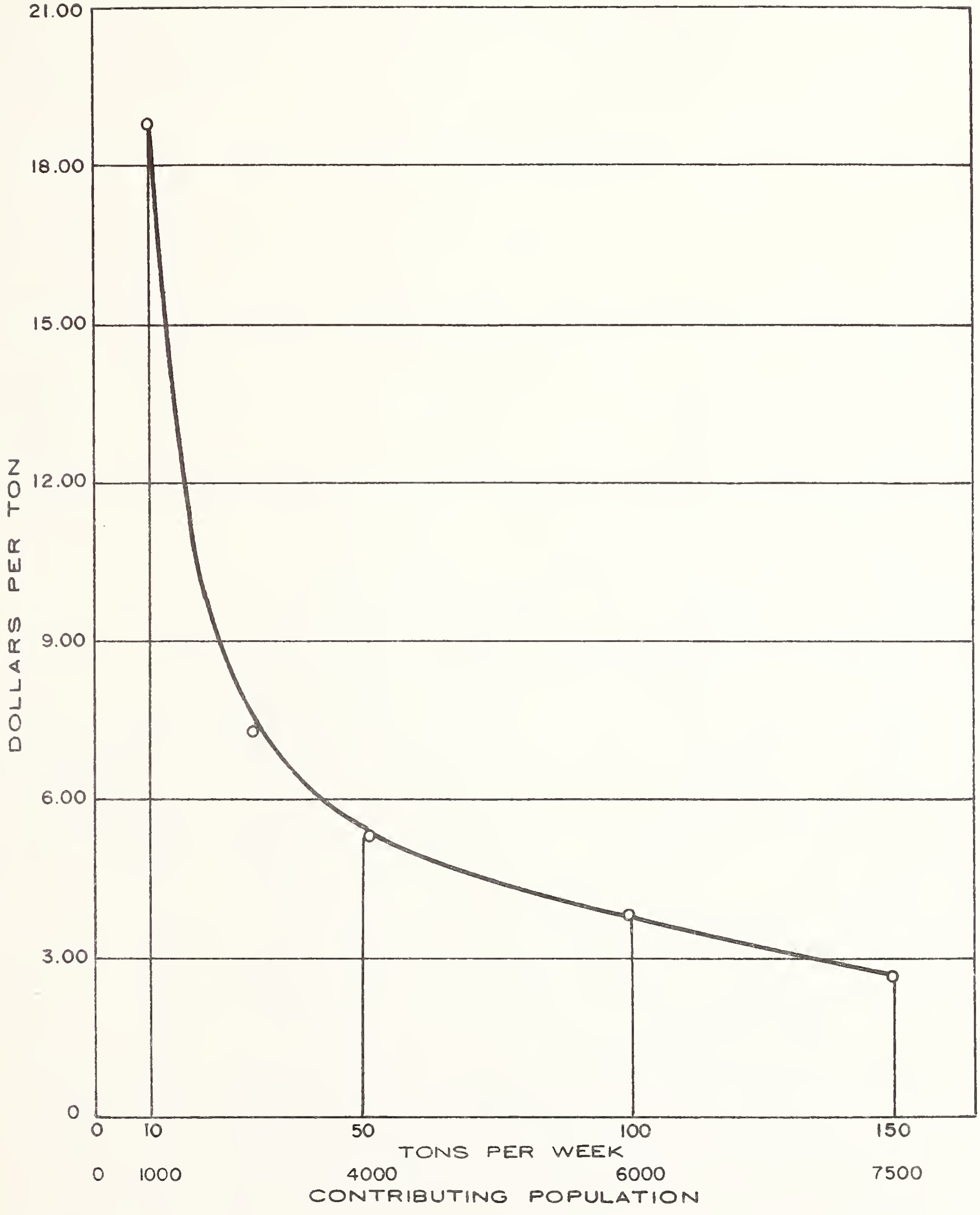
Summarized in Table III-4 are the capital and annual costs for transfer stations to serve various contributing populations. Also depicted is the type station which was determined applicable for each contributing population group. As indicated, the use of a non-compacted roll-off station is most applicable for disposal areas where less than 10 tons per week of waste is generated. (This represents a contributing population of less than 1000). For situations in which 1,000 to 10,000 people are served in a local area, a simple compacted transfer station will suffice in most instances. For areas with contributing populations in excess of 10,000, either a single or double push pit transfer station should be utilized, depending upon the local conditions and waste collection practices.

The cost per ton to operate the various size transfer stations are summarized in Figures III-6 and III-7. These figures illustrate the economies of scale. The cost per ton decreases as the tonnage increases. For example, a transfer station unit cost for handling 10 tons per week of waste is approximately $18.80 per ton. This compares to a unit cost of $1.43 per ton when approximately 2,000 tons per week of waste is handled. Thus, depending upon the haul distances involved, it may be more economical to strategically locate a few large transfer stations rather than locating several small transfer stations in an area.

TABLE III-4

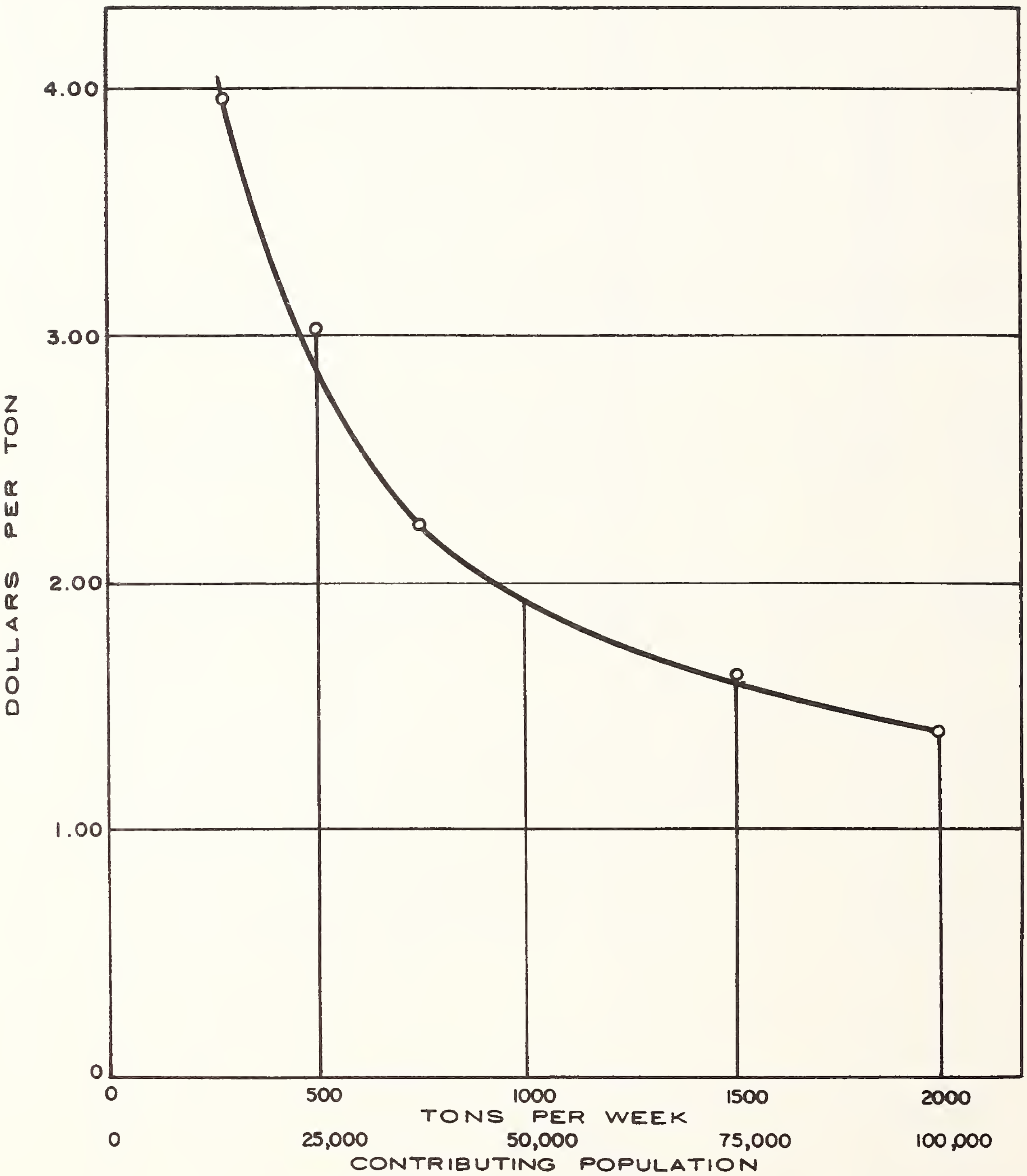
TRANSFER STATION COST SUMMARY

Facility Size TPW	10	30	50	100	150	250	500	750	1,500	2,000
Estimated pop. served	1,000	2,400	4,000	6,000	7,500	12,500	25,000	37,500	75,000	100,000
Facility Type	----- Simple Compacted -----					------ Single Push Pit ------			---Double Push Pit--	
Capital Costs										
Site Work, Utilities and Paving	$18,100	$18,100	$18,100	$ 18,100	$ 18,100	$ 23,500	$ 23,500	$ 23,500	$ 40,700	$ 40,700
Buildings	$ 9,100	$ 9,100	$ 9,100	$ 24,100	$ 24,100	$ 84,900	$ 86,100	$ 86,100	$168,600	$168,600
Equipment	$32,000	$32,000	$50,000	$ 50,000	$ 50,000	$ 72,000	$100,000	$100,000	$149,500	$149,500
Contingencies, Legal & Engr. @ 15%	$ 8,900	$ 8,900	$11,600	$ 13,800	$ 13,800	$ 27,100	$ 31,400	$ 31,400	$ 53,800	$ 53,800
Total	$68,100	$68,100	$88,800	$106,000	$106,000	$207,500	$241,000	$241,000	$412,600	$412,600
Annual Cost										
Equip. Maint. Oper. & Depreciation	$ 300	$ 700	$ 1,200	$ 2,500	$ 3,750	$ 6,250	$ 12,500	$ 18,500	$ 37,500	$ 50,000
Site Maint. & Oper.	$ 600	$ 600	$ 600	$ 1,000	$ 1,000	$ 2,100	$ 2,100	$ 2,300	$ 3,700	$ 3,700
Labor (including benefits @ 30%)	$ 1,800	$ 1,800	$ 2,400	$ 5,400	$ 10,900	$ 21,150	$ 39,500	$ 29,500	$ 47,300	$ 49,300
Amortization of Capital 20 yr. @ 7.5%	$ 6,700	$ 6,700	$ 8,700	$ 10,400	$ 10,400	$ 20,400	$ 23,600	$ 23,600	$ 40,500	$ 40,500
Total Annual Cost	$ 9,400	$ 9,800	$12,900	$ 19,300	$ 26,000	$ 49,900	$ 77,700	$ 83,900	$129,000	$143,500
Cost Per Ton	$ 18.80	$ 6.53	$ 5.16	$ 3.86	$ 2.48	$ 3.99	$ 3.11	$ 2.24	$ 1.72	$ 1.43



TRANSFER STATION COSTS
10 - 150 TONS PER WEEK

FIGURE III - 6



TRANSFER STATION COSTS
150 - 2000 TONS PER WEEK

FIGURE III - 7

PART FOUR

ANALYSIS OF PROCESSING ALTERNATIVES

PART FOUR

ANALYSIS OF PROCESSING ALTERNATIVES

A. GENERAL

Processing is an independent intermediate step in the overall system of solid waste collection, transportation, utilization and disposal. The primary function is to accomplish some level of materials separation and/or fuel preparation. Processing may be accomplished at a transfer point, or in conjunction with an energy recovery facility or a materials market. The degree of processing is dictated by the demand and market for recoverable components and by the subsequent use of the processed material.

Table IV-1 lists manufacturers offering various equipment components associated with solid waste processing systems. A total of seventeen solid fuel processing systems are identified and described. Although there are variations, the basic method of operation is to receive and shred the incoming refuse, in some cases air classify the shredded material, and generally to magnetically recover the ferrous fraction. The object is to produce a homogenous fuel product. This type of technology is currently well developed and most resource recovery systems incorporate standard equipment components in their processing schemes.

Based on the available technology for processing and utilizing solid waste, alternative systems were developed for the potential applicable resource recovery situations in the state. It was determined that three degrees of processing could be required. The descriptions and cost summaries for the three processes are included in Sections B, C and D of this part. A detailed breakdown of the design and operating criteria and costs associated with each alternative are included in Appendix C.

B. PRELIMINARY PROCESSING MODE

1. General Description. This mode includes the shredding and removal of ferrous metals. This degree of processing can be used for two situations in the state; (1) a preliminary processing system which shreds the waste prior to landfilling, and (2) the preparation of a feedstock for use in a pyrolysis system. The advantages of shredding prior to landfilling include: (1) reduction of transportation costs, (2) shredded solid waste may be landfilled without the requirements of daily cover, (3) rodents do not thrive in shredded solid waste, and (4) by utilizing magnetic separation equipment the ferrous metals can be recovered and sold. For pyrolysis, the major reasons solid waste is processed is to obtain a more homogenous feedstock and to recover the ferrous metals.

In this preliminary processing alternative, the waste is transported to the processing facility, is deposited in an enclosed tipping and storage area, and

TABLE IV - I

SOLID FUEL PROCESSING SYSTEMS

COMPANY NAME	RECEIVING AREA TYPE	CAPACITY	PRODUCTS: RDF	PRODUCTS: Fe	PRODUCTS: NON Fe METALS	PRODUCTS: GLASS	PRODUCTS: PAPER	PRODUCTS: OTHER	PROCESS: SHREDDING 1st STAGE	PROCESS: SHREDDING 2nd STAGE	PROCESS: AIR SEP.	PROCESS: INTERMED. STORAGE	PROCESS: SEWAGE SLUDGE	PROCESS: CHEM. TREATING	PROCESS: OPT-ING	PROCESS: OTHER	SUPPLIER CONTRACTUAL ARRANGEMENTS: DESIGN	SUPPLIER CONTRACTUAL ARRANGEMENTS: CONSTR.	SUPPLIER CONTRACTUAL ARRANGEMENTS: OPERATE	SUPPLIER CONTRACTUAL ARRANGEMENTS: FI-NANCE	SUPPLIER CONTRACTUAL ARRANGEMENTS: LOCAL OWNER-SHIP	SUPPLIER CONTRACTUAL ARRANGEMENTS: LOCAL FINANCE	CURRENT STATUS	REMARKS
AENCO, INC.	TIPPING FLR	100 TPH	X	X			X		2 SUPER IMPOSED		X	X				NEW ADS DEV.	X	X	X	-			PROCESSING PLANT AT WILMINGTON, DEL.	2-STAGE GRUENDLER 50 TPH SHREDDING TO LANDFILL ALSO DEVELOPING PROPRIETORY ADS SEPA-RATOR BEFORE SHREDDING
AMEND WASTE CONVERSION CORP.	-	1000 TPD	4	X					X	X	X												HAS NOT SOLD A SYSTEM	
ALLIS-CHALMERS	PIT-CONVEYOR	30 TPH		X					X		BEING IN-STALLED		X				X				X	X	UNDER DEVELOPMENT	PILOT PLANT LOCATED OUTAGAMIE COUNTY, WISCONSIN
AMAX., INC.	TIPPING FLR.	2000 TPD 3 LINES	X	X	X		X		X	X	X	X											HAS NOT SOLD A SYSTEM	NEGOTIATING W/MONTGOMERY COUNTY, OHIO
AMERICOLOGY, INC.	TIPPING FLR	500 TPD MODULAR UNIT	X	X	X		X		X		X						X	X	X				UNDER CONSTRUCTION-MILWAUKEE, WIS.	OPERATIONAL 1977
BROWNING FERRIS		1000-3000 TPD	X	X			X		X		X	X					X		X				PILOT PLANT IN HOUSTON, TEXAS	PROPOSED TO CITY OF MEMPHIS, TENN
COMBUSTION EQUIPMENT ASSOCIATES	-	1200 TPD	X	X					X		X			X	X	CHEM TREAT	X	X	X				1200 TPD FACILITY-BROCKTON MASSACHUSETTS-CONSTRUCTION	OFFER ECO-FUEL I & II
CONTINENTAL CAN CO.	PIT-DOZER	1400 TPD		X	X	X			X	X		X									X	X	HAVE NOT YET BUILT ENTIRE SYSTEM	SEVERAL FERROUS METAL RECOVERY FACILITIES, WILMINGTON, DEL., BALTIMORE, ETC.
THE NEIL COMPANY	TIPPING FLR	20 TPH/ LINE	X	X					X				X		X	VIB SCREEN	X				X	X	HAS NOT BUILT A SYSTEM	PACKAGED SYSTEM OFFERS ENRICHED RDF
RAYTHEON SERVICE CO.	-	-	X	X	PROPR				X	X	PROPR. DRUM ADS						X	X	X		X	X	UNDER CONTRACT W/MONROE, CO. N.Y.	BUREAU OF MINES TECHNOLOGY
RESEARCH COTTRELL	TIPPING FLR	2-30 TPH/ LINES 1000 TPD	X	X	X				X	X	X	X			X	TROM.							HAS NOT BUILT A SYSTEM	
SCA SERVICES, INC.	NOT A HARDWARE SUPPLIER MFGR.																	X	X				E. BRIDGEWATER, MASS. SYSTEM OPERATOR	WILL EVALUATE A DESIGN, THEN CONTRACT TO BUILD AND OPERATE THE SYSTEM
SIRA INTERNATIONAL	PIT-CONV.	1000 TPD	X	X	X	X			X	X	PROPR. DEVICE				X	B.S.	X	X	X		X	X	SOLD PILOT PLANT TO VISTA FIBER & CHEM.	HAS NOT SOLD PROTOTYPE SYSTEM
TELEDYNE NATIONAL		1500 TPD	2	X	X	X			X		X	X					X	X	X		X	X		PRIME CONTR.- BALTIMORE COUNTY
VISTA CHEMICALS & FIBER PRODUCTS	TIPPING FLR	500 TPD	X	X					X		X	X				PELL							OPERATING & MODIFYING FORMER SIRA PILOT PLANT	HAVE NOT SOLD THEIR SYSTEM
WASTE CONTROL SCIENCES	LIVE CONVEYOR	100 TPH	X	X	X	X			X	X	X				X	TROM							HAVE NOT SOLD THIS SYSTEM	REITERATION OF SIRA PROCESS

NOTE: ADS - AIR DENSITY SEPARATION
VTB - VIBRATION SCREEN
PELL - PELLITZING
TROM - TROMMEL
B.S. - BALLISTIC SEPARATOR

then is pushed onto a conveyor with a front-loader. The waste is then conveyed to a shredder, rated at a throughput of 50 tons per hour, which will reduce the material to a nominal 6 inch maximum size. The shredded material is then passed under a mechanical magnetic belt separator where the ferrous metals are removed and conveyed to storage. In this process, approximately 90 percent of the iron and steel is recovered from the solid waste. Then, depending upon final use, the shredded material is either conveyed to a stationary compactor for transfer to a disposal site or is conveyed to a storage bin.

Figure IV-1 shows a detailed site and building layout for this processing alternative.

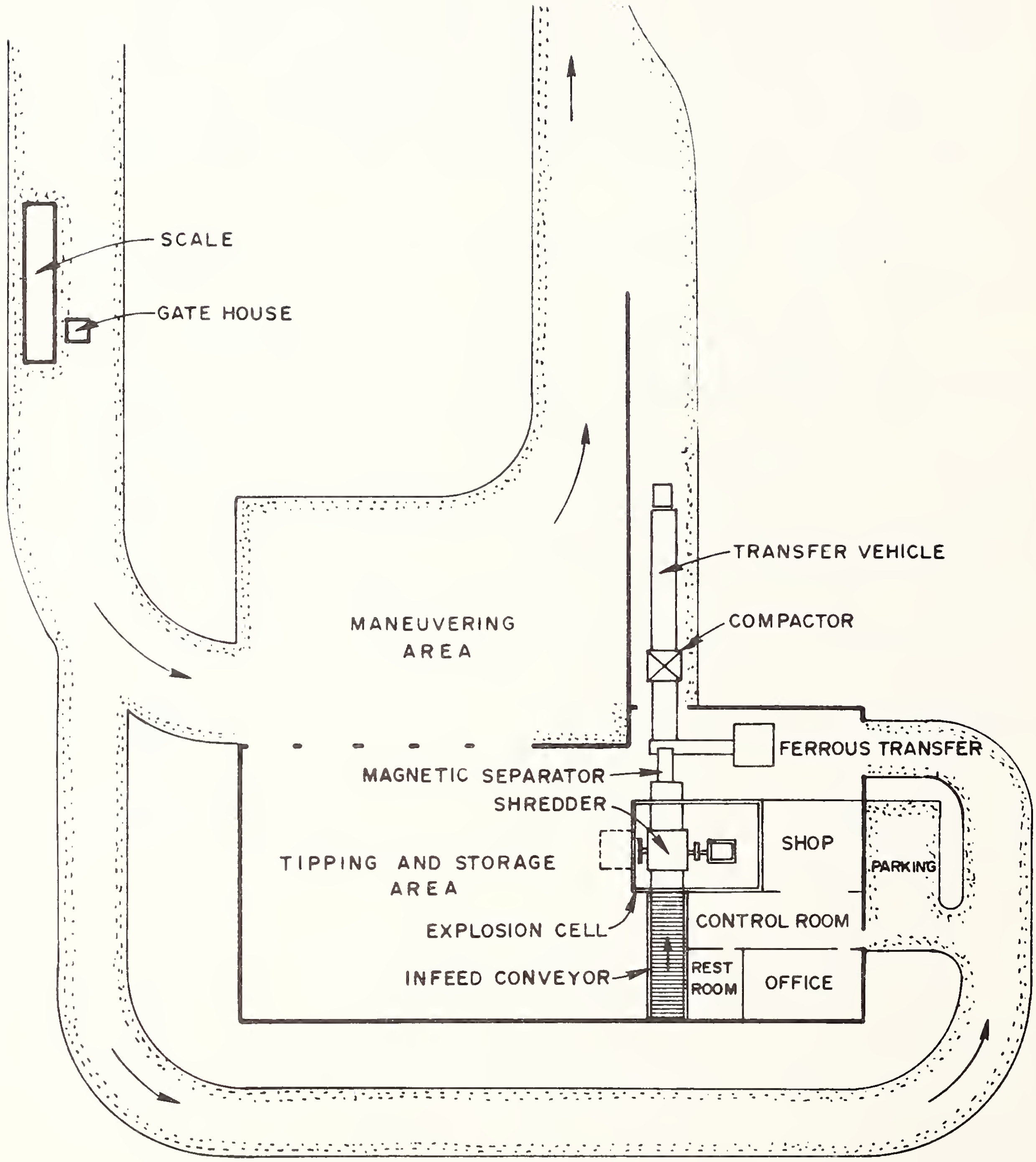
2. Cost Estimates. The capital and annual costs for the shred-landfill and the pyrolysis feedstock alternatives are shown in Tables IV-2 and IV-3 respectively. As the tables show, the capital expenditure for the two alternatives are $1,794,000 and $2,171,000 respectively. The difference in cost is due to the addition of a storage bin for pyrolysis. The annual costs were determined for three levels of daily throughput to determine the sensitivity of operating the facility at less than its rated capacity of 50 tons per hour. As the table shows, if the processing equipment is operated for 8 hours per day (400 tons per day), the unit cost per ton to process the waste varies from $4.71 to $5.32 depending upon whether the product is landfilled or utilized as pyrolysis feedstock. If 125 tons per day of waste is processed, the unit cost per ton increases to $10.19 or $11.54 respectively. The advantage of maximizing utilization is obvious.

The basis for the capital and annual costs summarized in Tables IV-2 and IV-3 are included in Appendix C. Also included is a detailed cost breakdown of the items listed in the tables.

C. STOKER BOILER FUEL PREPARATION MODE

1. General Description. This process is applicable when the combustible fraction of the processed waste will be burned as a primary or a supplemental fuel in an existing or new boiler designed to burn a solid fuel on a grate. In Montana, this process is most applicable where a present or proposed grate type boiler is utilizing or will utilize either stoker coal or chipped wood wastes (commonly referred to as hog fuel). This process is the same as preliminary processing with one exception; air classification has been added to the equipment line. The purpose of air classifying the shredded refuse is to separate the lighter combustible material from the heavier non-combustible material.

The operational procedures of this alternative are very similar to the preliminary processing alternative discussed in Section B. The waste is deposited on a tipping floor and pushed onto a conveyor which feeds a fifty ton per hour



PRELIMINARY PROCESSING PLANT

FIGURE IV - 1

TABLE IV-2

SHRED-LANDFILL PROCESSING COST SUMMARY

Capital Cost

Item	Cost
Site Work and Utilities	$ 151,000
Buildings	475,000
Major Equipment	466,000
Electrical and Mechanical and Spare Parts	303,000
On-Site Rolling Equipment	85,000
Engineering and Contingencies	314,000
Total Capital Cost	$ 1,794,000

Annual Cost

Facility Processing Rate (5 Days/wk.)	125 TPD	250 TPD	400 TPD
Site & Building Maint.	$ 13,100	$ 13,500	$ 13,900
Mechanical and Electrical	26,800	32,400	38,400
Shredder Maintenance	16,200	32,500	52,000
Electrical Power	32,500	65,000	104,000
Labor	49,800	56,200	79,500
Rolling Stock, O&M	13,900	18,600	23,300
Amortized Capital Cost (20 Yrs. @ 7.5%)	$ 179,000	$ 179,000	$ 179,000
Total Annual Cost	$ 331,300	$ 397,200	$ 490,100
Cost Per Ton	$ 10.19	$ 6.11	$ 4.71

TABLE IV-3

PYROLYSIS FEEDSTOCK PROCESSING COST SUMMARY

Capital Cost

Item	Cost
Site Work and Utilities	$ 151,000
Buildings	439,000
Electrical and Mechanical and Spare Parts	394,000
Major Equipment	587,000
On-Site Storage	170,000
On-Site Rolling Equipment	85,000
Engineering and Contingencies	345,000
Total Capital Cost	$ 2,171,000

Annual Cost

Facility Processing Rate	125 TPD	250 TPD	400 TPD
Site and Building Maintenance(5 days/wk.)	$ 18,100	$ 18,500	$ 18,900
Mechanical & Electrical	26,800	32,400	38,400
Shredder Maintenance	16,200	32,500	52,000
Electrical Power	32,500	65,000	104,000
Labor	49,800	56,200	79,500
Rolling Stock,O&M	13,900	18,600	23,300
Amortized Capital Cost (20 Yrs. @ 7.5%)	$217,700	$ 217,700	$ 237,700
Total Annual Cost	$375,000	$ 440,900	$ 553,800
Cost per Ton	$ 11.54	$ 6.78	$ 5.32

shredder after which the ferrous fraction is magnetically removed from the shredded material. The relatively ferrous free material is then mechanically conveyed to a surge bin and air classifier. In the air classifier the lighter density material is entrained in a rising air current while the heavier material drops through the throat of the classifier onto a conveyor. The heavy material, which is landfilled, represents approximately 15% to 25% of the incoming processable waste. The light fuel fraction is subsequently removed from the air stream by a cyclone separator. The air then passes through an induced draft fan and cleaned through filter bags before reuse in the air classifier. The fuel fraction is mechanically conveyed to storage bin and then reclaimed for energy recovery.

A detailed building, equipment and site layout for this alternative is shown in Figure IV-2. The layout is similar to the preliminary process layout with the addition of the air classification equipment.

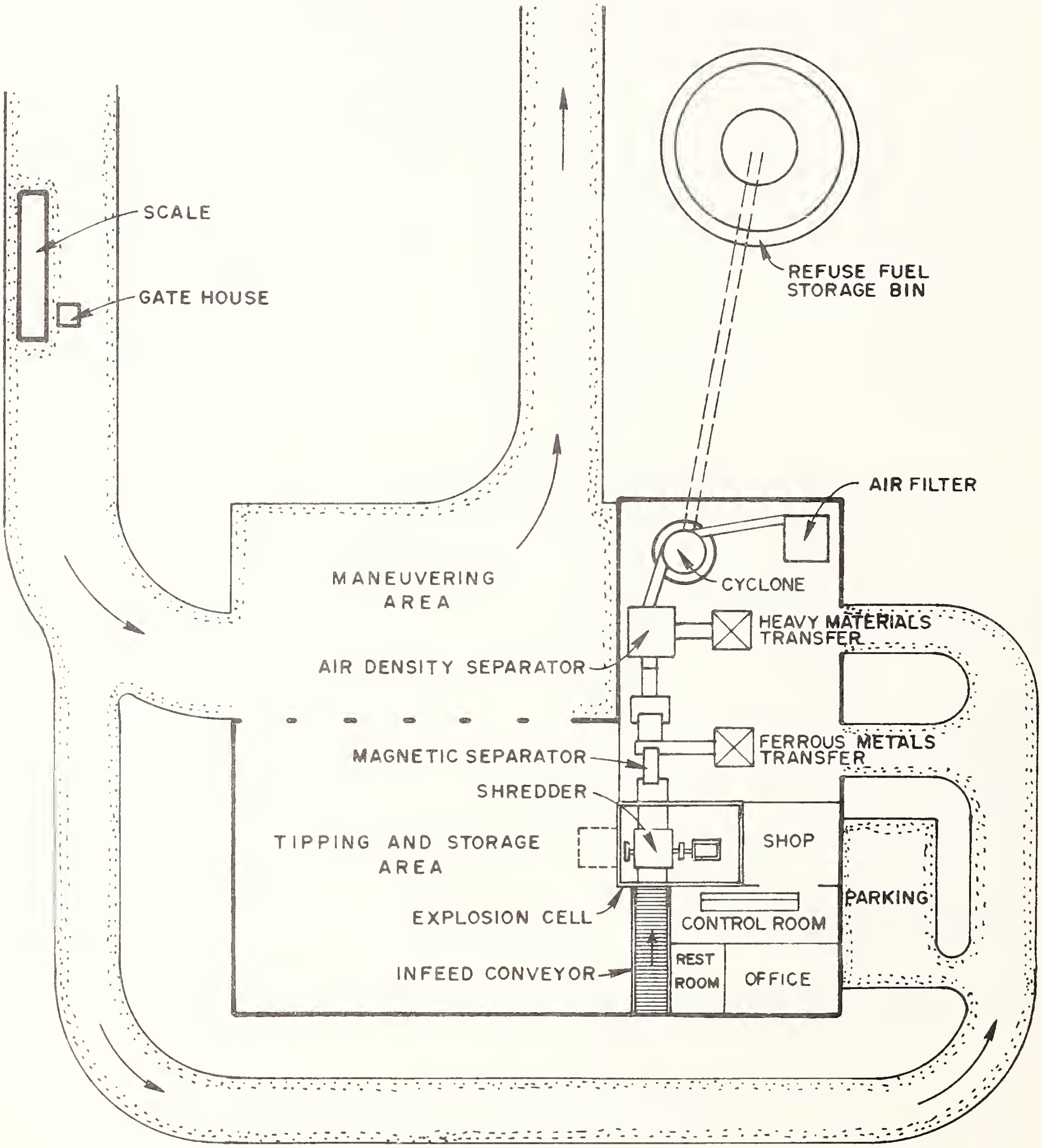
2. Cost Estimates. The capital and annual costs for this alternative are summarized in Table IV-4. A detailed cost breakdown and basis is included in Appendix C. As shown, a capital expenditure of $2,823,000 is required to prepare solid waste for use as primary or supplemental fuel in a stoker type grate boiler. This represents an increase of approximately one million dollars when compared to the preliminary processing mode discussed in Section B.

Table IV-4 also summarizes the annual cost to operate the processing plant. The annual cost includes site and equipment maintenance and operational expenses, labor, and amortization of the capital investment. As shown, the unit cost per ton to process the waste for utilization as a solid fuel in a stoker grate type boiler varies from $13.91 to $6.15 per ton depending upon the quantity of waste processed. The system has a 50 ton per hour operating capacity and as the table shows, the unit costs are lowest when the system is operated at its capacity.

D. SUSPENSION FIRED BOILER FUEL PREPARATION MODE

1. General Description. This process is applicable when the combustible fraction of waste is to be utilized as a fuel source in a suspension fired boiler. In order for solid waste to be burned in suspension, the particle size must be reduced to a nominal one inch size. This compares to a required nominal size of 3 to 5 inches when waste is burned in a grate type boiler. The process required to produce a fuel which can be utilized in a suspension fired boiler includes two stages of shredding and air classification. Figure IV-3 depicts the flow diagram and equipment requirements for this alternative.

In this process, incoming refuse is initially shredded to a nominal six inch size in a 50 ton per hour shredder. The ferrous material is then recovered



STOKER BOILER FUEL PROCESSING PLANT

FIGURE IV - 2

TABLE IV-4

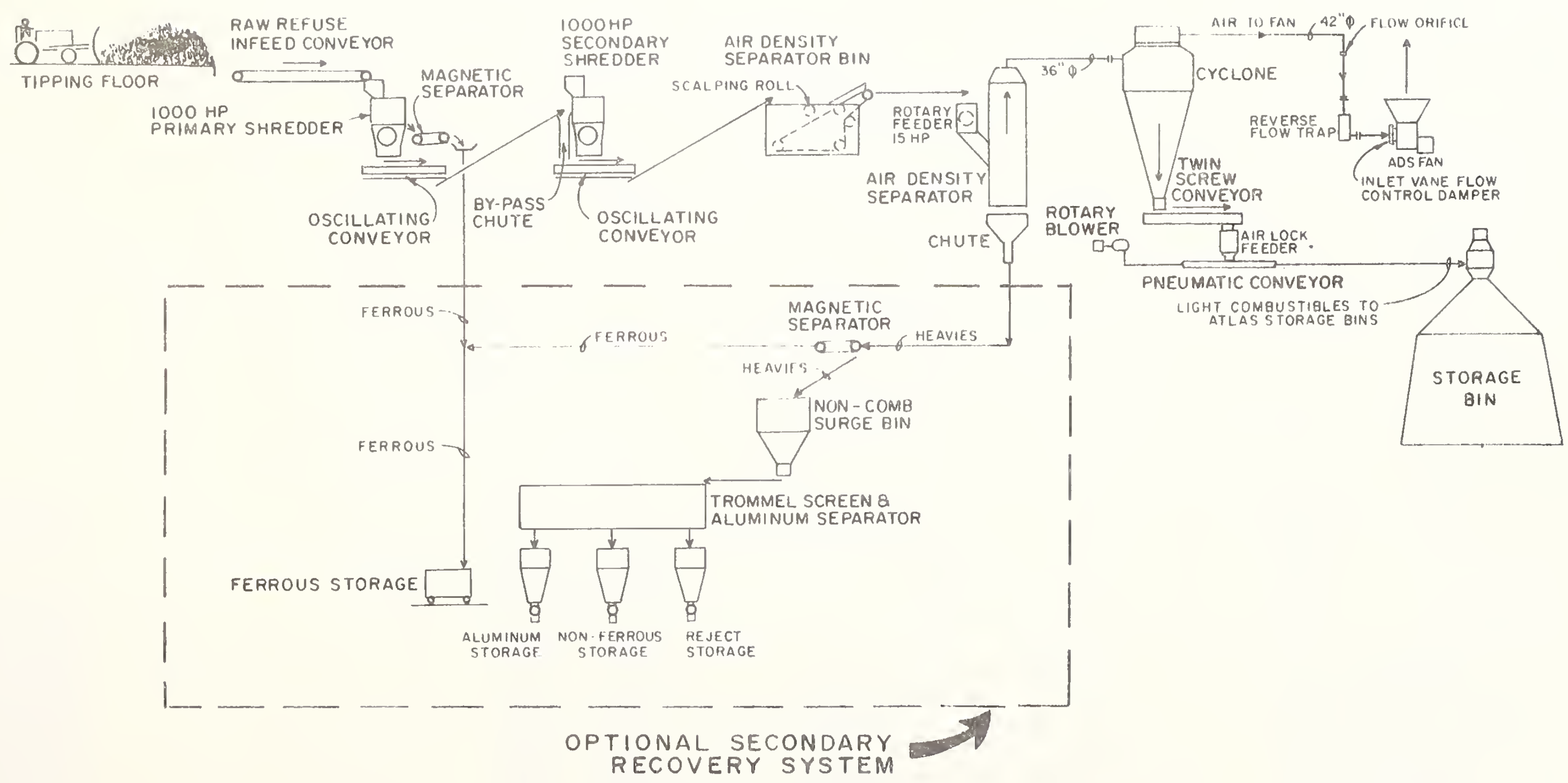
STOKER GRATE TYPE BOILER PROCESSING COST SUMMARY

Capital Cost

Item	Cost
Site Work and Utilities	$ 151,000
Building	534,000
Electrical, Mechanical and Spare Parts	562,000
Major Equipment	872,000
On-Site Storage	170,000
On-Site Rolling Equipment	85,000
Engineering and Contingencies	449,000
Total Capital Cost	$2,823,000

Annual Cost

Facility Processing Rate (5 days/wk.	125 TPD	250 TPD	400 TPD
Site and Building Maintenance	$ 19,500	$ 19,900	$ 19,300
Mechanical & Electrical	35,200	42,500	50,600
Shredder Maintenance	16,200	32,500	52,000
Electrical Power	32,500	65,000	104,000
Labor	57,900	80,500	93,300
Rolling Stock	13,900	18,600	23,300
Amortized Capital Cost (20 Yrs. @ 7.5%)	$277,000	$277,000	$297,000
Total Annual Cost	$452,200	$356,000	$639,500
Cost per Ton	$13.91	$8.25	$6.15



SUSPENSION FIRED BOILER PROCESSING FLOW DIAGRAM

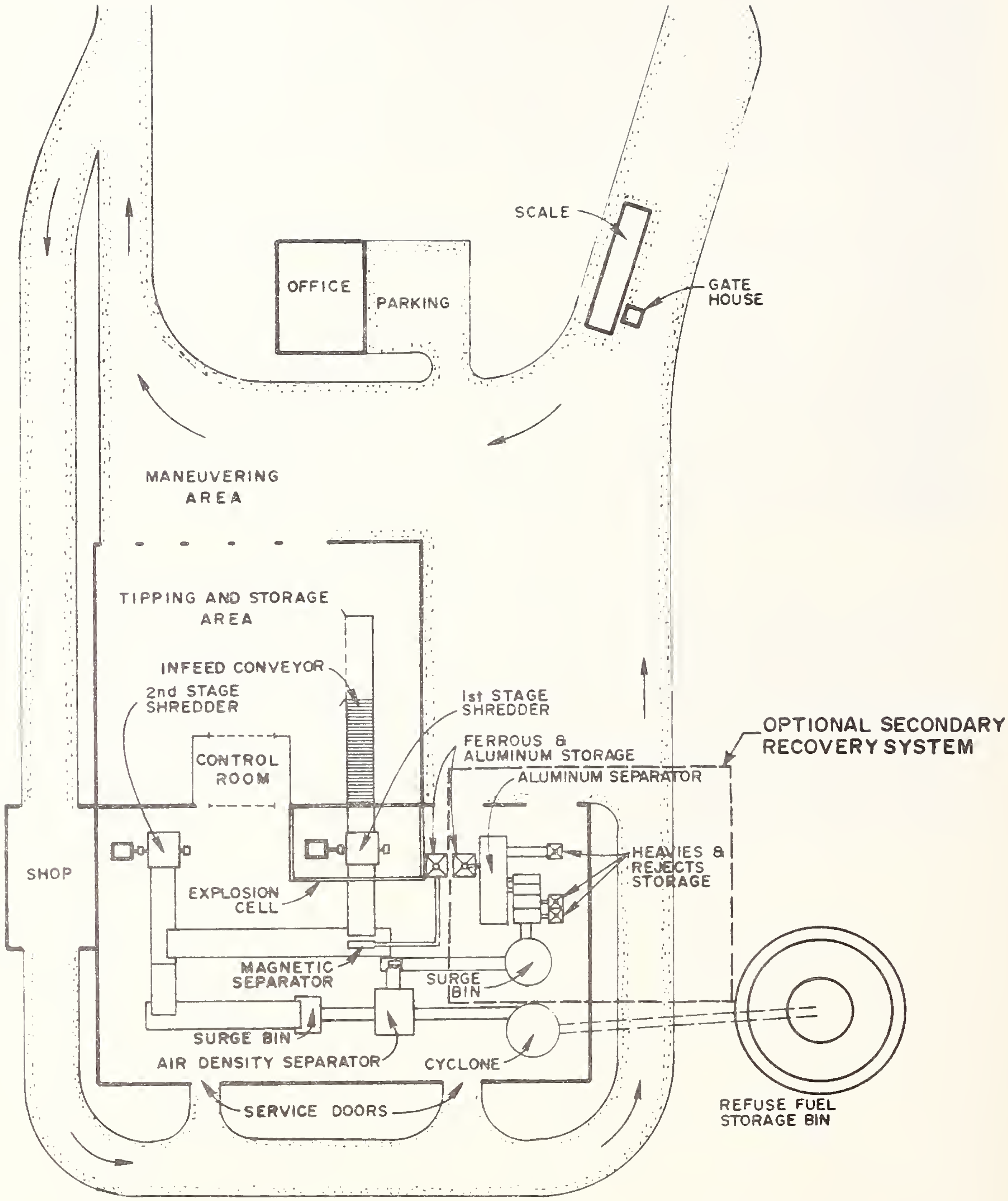
FIGURE IV - 3

and the shredded refuse conveyed to a second shredder where the material is reduced to an approximate one inch nominal size. The finely shredded material is then mechanically conveyed to an air classifier for separation of the combustible and non-combustible materials. The non-combustibles may be conveyed to a further separation system where the ferrous, aluminum and other non-ferrous metals are separated from the dirt, glass and rejects. The recoverable metals are then conveyed to storage and subsequently sold. The reject material will be landfilled.

A building, equipment and site layout for this processing alternative is shown in Figure IV-4.

2. Cost Estimates. The capital and operating costs for this alternative are summarized in Table IV-5. As shown, the capital cost is approximately $5.2 million dollars. In comparison this represents approximately twice the capital cost for processing waste for use in a stoker grate type boiler. The main reason for the increase is the larger building size requirements and the additional pieces of equipment required. A detailed basis for the costs is outlined in Appendix C of this report.

Table IV-5 also summarized the annual cost to operate the processing plant. As shown, the unit cost per ton to operate the facility ranges from $10.00 to $23.67 depending upon the quantity of waste processed. These costs are considerably higher than the unit costs to process waste for use in a grate type boiler. It should be noted, however, that increased revenues can be obtained due to the non-ferrous metal separation system which is included. It is anticipated that the revenue from these metals would partially offset the higher unit processing costs.



SUSPENSION FIRED BOILER PROCESSING PLANT

FIGURE IV - 4

TABLE IV-5

SUSPENSION FIRED BOILER PROCESSING COST SUMMARY

Capital Cost

Item	Cost
Site Work and Utilities	$ 151,000
Buildings	894,000
Electrical, Mechanical and Spare Parts	1,237,000
Major Equipment	1,845,000
On-Site Storage	170,000
On-Site Rolling Equipment	85,000
Engineering and Contingencies	855,000
Total Capital Cost	$5,237,000

Annual Cost

Facility Processing Rate (5 Days/Wk.)	125 TPD	250 TPD	400 TPD
Site and Building Maintenance	$ 28,600	$ 29,100	$ 29,600
Mechanical & Electrical	65,500	65,500	65,500
Shredder Maintenance	28,300	56,500	90,500
Electric Power	56,900	113,700	182,000
Labor	64,300	93,300	114,300
Rolling Stock	12,000	16,600	23,300
Amortized Capital Cost 20 Yrs. x 7.56)	$513,800	$513,800	$533,800
Total Annual Cost	$769,400	$888,500	$1,039,000
Cost per Ton	$23.67	$13.67	$10.00

PART FIVE

ANALYSIS OF WASTE UTILIZATION ALTERNATIVES

PART FIVE

ANALYSIS OF WASTE UTILIZATION ALTERNATIVES

A. GENERAL

The purpose of this section of the report is to present an analysis of the solid waste utilization techniques which have applicability in the State of Montana. Initially to determine which techniques are most applicable, the utilization processes presently being marketed or used elsewhere were analyzed. It was determined that there are three basic types of systems applicable in the state. The present technology and costs of each are summarized herein.

1. Direct Combustion. The most prominent and favorable energy conversion system is the utilization of processed solid waste as a fuel source in various type boilers to produce steam for heating, cooling and/or electrical generation. There are a large number of such facilities operating. For this project twenty such systems were reviewed and evaluated.

Table V-1 lists the general characteristics of each system. Some of these companies are leaders in the industry, while others are not as well known. Each of the companies listed has a system which receives municipal solid waste, accomplishes processing and converts the combustible fraction into some form of usable energy. These systems employ various combustion processes to produce electrical energy, steam, heating and air conditioning outputs. These can be produced by utility or industrial boilers, fluid beds and waterwalled boiler systems.

2. Pyrolysis. The second conversion system which was analyzed was the pyrolysis of solid waste. The primary objective of the pyrolysis concept is to recover the gases and/or oils generated when solid waste is heated to high temperatures under controlled conditions. Pyrolysis is a concept used for many years in the coking industry. Its application to solid waste has evolved in the last five years. Fourteen companies offering pyrolysis systems were identified. Table V-2 lists the characteristics associated with the individual pyrolysis systems. Their development ranges from paper concepts to working units. All of the systems are based on a common principle; destruction of municipal waste is accomplished in an oxygen-starved atmosphere to produce products such as heat, synthetic gas, certain petrochemicals and char. The apparent advantages of the pyrolysis systems are the low degree of air emissions and the production of marketable energy products such as pyrolysis gas, oil or the subsequent production of steam. Several of the listed manufacturers are capable of demonstrating their systems. In other instances, significant development work beyond the pilot plant level needs to be completed before serious consideration can be given to their use in a large-scale resource recovery system.

TABLE V - I

ENERGY CONVERSION SYSTEMS BY DIRECT COMBUSTION

COMPANY NAME	RECEIVING AREA TYPE	CAPACITY	PRODUCTS						REFUSE PROCESSING						TYPE OF COMBUSTION	CONTRACTUAL ARRANGEMENTS					CURRENT STATUS	REMARKS
			STEAM	ELEC. POWER	Fe.	Al.	GLASS	OTHER	1ST STAGE SHREDDING	2nd STAGE	MAG SEP.	SHRED BULKY WASTES ONLY	AIR SEP	OTHER		DESIGN	CON-STRUCT	OP-ERATE	FINANCE	LEASE		
BLACK-CLAWSON	-	2000-3000 TPD	X	X	X	X	X		X	X	X		X	GLASS	FLUID BED INCINERATOR	X	X	X			AWARDED CONTRACT IN MAY 1975	PILOT PLANT IN MIDDLETOWN, OHIO
CICO RES. REC. SYSTEMS	-	50-100 TPD						NONE							INCINERATOR						NO RESPONSE	SMALL BATCH, WADEG INCINERATOR
CLEAR AIR, INC.	FLOOR	MODULES 150TPD UNIT	X	OPTION	FROM ASH	FROM ASH	FROM ASH				NONE				MOVING GRATE INCINERATOR	X	X	X		X	300 TPD FACILITY OPERATING SINCE 1966 IN WEBER, UTAH	NO VOL. REDUCTION BEFORE INCINERATION
COMBUSTION EQUIP., ASSOC.			X	OPTION	X						ECO FUEL II				DOUBLE VORTEX BURNER	X	X				PROPRIETARY DESIGN	BURNER FOR USE WITH ECO-FUEL II FRONT END
COMBUSTION ENGINEERING		VARIOUS SIZED UNITS	X								VARIOUS LEVELS				BOILERS INCINERATORS	X					EXISTING EQUIPMENT	EXPERIENCE WITH RDF FIRING IN BOILERS
COMBUSTION POWER CO., INC.		MODULAR 400TPD/UNIT	OPTION	X	X	X			X		X	-	X		FLUID BED TO GAS TURBINE						400 TPD PILOT PLANT SCHEDULED LATE 1976	HIGH PRESSURE GAS TURBINE SYSTEM
CONSUMAT SYSTEMS	RAM LOADER	12.5 & 20.0 TPD/UNITS				NONE					NONE				BATCH LOADED	X					100 TPD PLANTS IN 4 LOCATIONS	NO MATERIALS RECOVERY
COPELAND SYSTEMS, INC.	OPTIONAL	650 TPD	X			NONE			X						FLUID BED INCINERATOR						UNIT INSTALLED AT GREAT LAKES PAPER CO.	SLUDGE OR SOLID WASTE DISPOSAL
ECOLOGENICS CORP.	FLOOR	-	X		X	X	X		X	X	X			TWO 3-STG STAGE SHRED	VERTICAL FURNACE						UNDER DEVELOPMENT	
GRUMMAN ECO-SYSTEMS	PIT-CRANE	1200 TPD	X		X	X	X	PAPER, COMPOST, PLASTIC	FLAIL	FLAIL			THREE STAGES	COMPOST. & Fe. KILN	BATCH LOADED MOVING GRATE INCINERATOR	X	X				ITALIAN SYSTEMS OPERATING IN EUROPE - e.g. ROME	HAS NOT SOLD A SYSTEM IN U.S.
HAMILTON STANDARD	-	-							NO INFORMATION						INCINERATOR						UNDER DEVELOPMENT WITH U.S. [illegible]	SMALL SCALE BELOW 10000 TPD
NASHVILLE THERMAL	PIT-CRANE	720 TPD	X		NONE				NONE						INCINERATOR	X	X	X	X		TWO 360 TPD UNITS ARE OPERATIONAL	ESTIMATED $ 8 MILLION TO CORRECT PROBLEMS
INTERNATIONAL ENVIRONMENTAL SYSTEMS CORP.									SAME AS UOP SYSTEM												IESC IS ASSOCIATED WITH UNIVERSAL OIL PROD.	
INTERNATIONAL INCINERATOR	CONVEYOR	-	OPTION		OPTION FROM ASH				NONE						ROTARY KILN INCINERATOR						VARIOUS INSTALLATIONS AROUND U.S.	
KCM ENTERPRISES		150 TPD	USED IN DRYING		FROM ASH				X					DRYING	ROTARY KILN						150 TPD PILOT PLANT OPERATING SINCE JUNE, 1974	HAS NOT SOLD A FULL SCALE SYSTEM
OVITRON CORPORATION									SAME AS UOP SYSTEM												ASSOCIATED W/IESC AND UNIVERSAL OIL PROD.	
UNION ELECTRIC CO-PROJECT	TRAILER/RAIL CONV.	8000 TPD	X	X	X	X	X		X	X	X		X	DETINNING PLT.	SUSPENSION	X	X	X	X		IN DESIGN STAGE	SCALE-UP OF EARLIER ST. LOUIS PLANT
UNIVERSAL OIL PRODUCTS	PIT-CRANE	500 TPD PER UNIT	X	OPTION	FROM ASH							X			MOVING GRATE STEAM BOILER	X	X	X	X		SEVERAL OPERATIONS-e.g. CHICAGO NORTHWEST	
VON ROLL LTD.									SAME AS WHEELABRATOR-FRYE												U.S. REPRESENTATIVE IS WHEELABRATOR-FRYE	
WHEELABRATOR-FRYE	PIT-	1000-1200 TPD	X		FROM ASH		FROM ASH					X				X	X	X	X	OWN	PLANT AT SAUGUS MASS.	START UP IN DEC. 1975

TABLE V - 2
PYROLYSIS SYSTEMS

COMPANY NAME	RECEIVING AREA TYPE	CAPACITY (TPD)	PRODUCTS								PROCESSING						CONTRACTUAL ARRANGEMENTS					CURRENT STATUS
			OIL	CHAR	GAS	STEAM	FE.	ALUM	GLASS	CHEM.	SHREDDING 1st STAGE	SHREDDING 2nd STAGE	AIR SEP.	INTERMED. STORAGE	DRY-ING	SEWAGE SLUDGE	HARD-WARE SUPPLIER	DESIGN	CON-STRUCT	OP-ERATE	FINANCE	
RESOURCE RECOVERY, LTD. PURETLC PROCESS	-	5 TPD PILOT		X	X		X-P	X-P	X-P	X	X		X	X	X							5 TPD PILOT PLANT IN IRVINE, CALIF.
CARBORUNDUM TORRAX PYROLYSIS SYSTEM	PIT-CRANE	30C TPD		X	X	X											X	X	X	X		SOLD TWO PLANTS IN EUROPE
DEVCO MANAGEMENT	PIT-CRANE	300 TPD		X	X	X	X-P	X-P	X-P		OPTION											200 TPD PILOT PLANT
ECOLOGY RECYCLING UNLIMITED, INC.	-	10 TPD PILOT PLANT			X						X									X		10 TPD PILOT PLANT
ENVIROMETRIX, INC.	-	-											X									HAS NOT SOLD A SYSTEM
KEMP WASTE SYSTEMS	-	5 TPD PILOT PLANT	X	X	X					X						X						5 TPD PILOT PLANT
MONSANTO (LANDGARD) SYSTEM	PIT-DOZER	1000 TPD		X	X	X	X-P		X-P		X			X		X		X	X			BALTIMORE, MARYLAND (AIR EMMISION PROBLEM)
OCCIDENTAL FLASH PYROLYSIS SYSTEM	-	200 TPD	X	X			X	X	X		X	X	X	X	X			X	X	X		200 TPD PILOT PLANT IN SAN DIEGO, CALIF. UNDER CONSTRUCTION
PAN AMERICAN RESOURCES (LANTZ CONVERTER)	-	6 TPD PILOT PLANT	X	X	X						X											WILL BE DESIGNED IN 300 TPD TRAINS
PYROLYSIS SYSTEMS, INC. -X50	PIT-CONV.	50 TPD TRAIN		X	X		X				X			X								CONTRACT TO DEMONSTRATE X-50 AT RIVERSIDE, CALIFORNIA
PYROTEX, INC.	FLOOR PIT CONVEYORS	240 TPD TRAIN		X	X		X	X			X		X	X	X							HAS NOT SOLD A SYSTEM
REOXER YOUNG PROCESSES, LTD.	PIT-CONV.	-	X	X	X		X	X	X	X	X	X			X							UNDER DEVELOPMENT
RESOURCE SCIENCES, INC.	(SEE 200)																					
UNION CARBIDE (PUROX) SYSTEM	OPTIONAL	350 TPD		X	X		X				X					TESTING	X	X		X		200 TPD PILOT PLANT AT SO. CHARLESTOWN, W.V.

P = POST

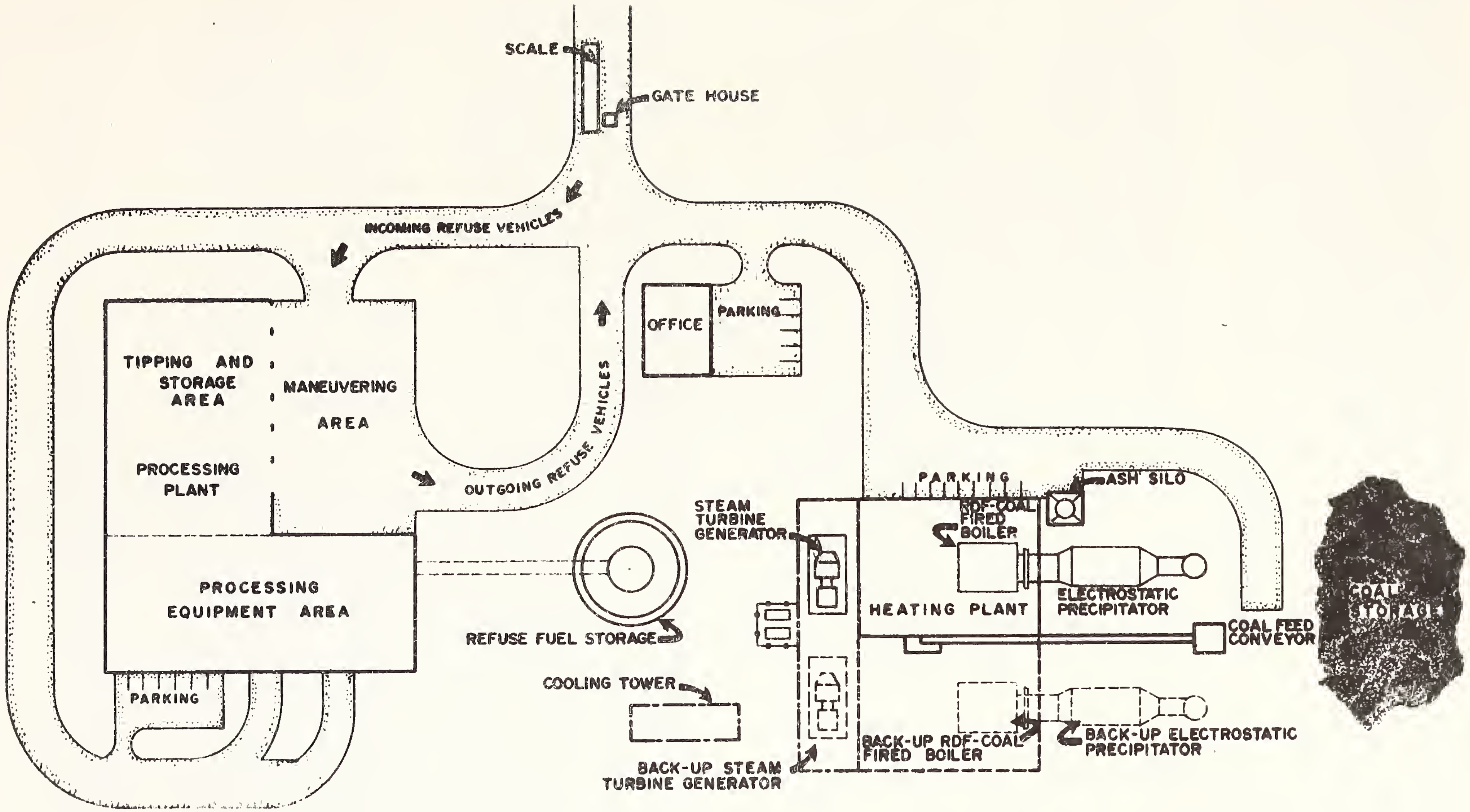
3. Composting. Composting is described as the rapid but partial decomposition of moist, solid, organic matter by the use of aerobic micro-organisms under controlled conditions. Two basic composting methods were analyzed for application in Montana: (1) the conversion of municipal and agricultural wastes into a commercial fertilizer by aerobic digestion, and (2) the use of processed solid waste as a soil conditioner to reclaim land which has been stripped of top soil.

Regardless of which application is implemented, the wastes should be processed to remove the metals, glass, plastic and other inert materials. The process required to do this is similar to the process required to prepare solid waste as a fuel in stoker fired boilers. To obtain a commercial fertilizer product from solid waste, the wastes after processing must be further treated in a mechanical compost plant. The end product is a fertilizer which is bagged and can be sold competitively with other types of commercial fertilizers. For the alternative of utilizing solid waste as a soil conditioner no further treatment is required after the inorganic materials have been removed. To be effective the organic fraction of the waste is simply tilled into the overburden soil. Through tests conducted at Montana State University, it has been determined that utilizing this method to replenish vegetation is as effective as replacing top soil and using fertilizer. The present disadvantage of utilizing solid waste as either a commercial fertilizer or soil conditioner is the economics. In most instances the processing costs are considerably higher than the present worth of the waste as a soil conditioner.

Based on the available technology and the potential marketable applications in the state, preliminary facility layouts and cost estimates for each of the three basic utilization systems were developed. These are discussed in detail in the following sections of this chapter. Costs and site layouts were developed for general applications and not for specific applications in the state.

B. ANALYSIS OF THE DIRECT COMBUSTION ALTERNATIVE

1. General. When solid waste is to be utilized as the primary source of fuel in a boiler, there are two basic products which can be marketed; steam and electricity. Because of the various conditions and applications in which solid waste can be utilized in boiler(s) to produce steam and/or electricity, equipment requirements and cost estimates were developed for four basic situations: (1) a steam plant for producing steam for heating, cooling and/or processing purposes, (2) a steam plant with a back-up boiler system, (3) a power plant capable of generating electricity, and (4) a power plant with a back-up generation system. Generally, the steam or electrical generation alternatives without backup are applicable in situations where several boilers are presently in use and a boiler designed to utilize solid waste is to be added to the total system. A steam or electrical generation alternative with back-up capabilities is necessary only in those situations where there are no other boilers in the system. A typical site layout which shows the solid waste processing, utilization and support facilities for each alternative analyzed is depicted in Figure V-1.



DIRECT COMBUSTION
SITE PLAN

FIGURE V - I

For each application analyzed the utilization processes were designed for approximately 225 tons per day of combustible material. Through previous waste generation, composition and market analyses, it was determined that approximately 300 tons per day would be an average accumulation of waste at any one site in the state. From composition studies it was determined that 300 tons per day of waste generated represents approximately 200-250 tons of combustible material. The remainder of the waste would either by recovered or require disposal.

Regardless of whether steam and/or electricity is to be produced, the solid waste must initially be processed. The required processing for utilizing waste in a stoker grate type boiler includes one stage of shredding, ferrous separation and air classification. A detailed layout of a typical processing plant capable of processing waste to this degree was shown in Figure IV-2.

2. Steam Plant Requirements and Costs. The facility anticipated for this application includes all the major equipment to generate steam, handle the material not burned, and treat the stack emissions to meet present air pollution standards. The boiler has the capacity to deliver 70,000 pph of 250 psig, 450° F steam when fired with 100 percent refuse derived fuel (RDF). This unit is equipped with stoker coal feeders for backup heat input to enable the plant to continue operation when RDF may be unavailable or received with excessively high moisture content. Normally, the boiler will operate on 90 percent RDF and 10 percent coal on a heat content basis. The boiler would be especially designed for high reliability and low maintenance.

The boiler is of the two-drum waterwall cooled furnace design. The unit is equipped with a traveling grate which would have continuous ash discharge. The boiler is equipped with regenerative combustion air heaters, sootblowers, refuse distributors, coal feeders and hoppers, mechanical draft fans, flame monitoring and safety controls. The boiler flue gas train is equipped with all necessary equipment required to meet current Federal and State air pollution emission standards. Electrostatic precipitators would most likely be used for particulate emission control.

The refuse derived fuel is introduced through special ports in the front wall of the furnace above the traveling grate. The RDF is continuously and automatically fed from the receiving hoppers. The rate of RDF firing is metered from the live bottom bin in which it is stored. Adjustable high velocity air jets in the ports disperse and distribute the RDF for optimum burning conditions. High pressure over-fire jets provide turbulence and thorough mixing of fuel and air to assure complete combustion. Fine particles of fuel are rapidly burned in suspension while coarse heavy particles fall to the grate where they have adequate time to complete combustion.

Two boiler feedwater pumps are also provided; one is motor driven and one steam driven (non condensing turbine). Each pump has the capacity of

supplying the total feedwater requirements of the boiler. A single deaerator adequate to heat and deaerate the feedwater requirements is provided. An integral condensate storage tank adequate for 30 minutes of plant operation is also included. A complete water treatment system for feedwater makeup is provided. The system would utilize a deionizer for a high purity makeup supply.

Bottom ash and precipitator fallout is removed and collected by a dry vacuum system which conveys the ash in a dry state by pneumatic pipeline to an overhead dry storage silo. The silo has two days of storage capacity and is emptied through a water mixing dustless unloader by gravity to open trucks for transportation to a landfill.

The RDF is conveyed from the processing plant to a 500 ton capacity live bottom storage bin located adjacent to the power plant. When the bin is full the plant can continue to generate steam from the RDF for approximately two days. This storage system increases the flexibility in the operation of both the processing plant and the power plant because it reduces the need to closely coordinate the schedules of these facilities. RDF enters the top of the bin by mechanical conveyor, then falls by gravity to the floor of the bin forming a conical pile. Fuel is reclaimed by a system of sweeping buckets and drag conveyor which cut the fuel from the bottom edges of the pile at an adjustable rate of flow and delivers it to a single mechanical conveyor.

Coal bunkers are provided inside the building for storage. A coal pile adjacent to the boiler building provides for outside storage. Conveyor equipment is provided to raise the coal to the bunkers from either the coal pile or from a coal hopper alongside of the building. Rail sidings would be included to deliver coal to the storage pile or directly to a live bottom coal hopper.

The boiler and auxiliary equipment, except the electrostatic precipitator and I. D. fan, is enclosed within an insulated metal wall panel and structural steel formed building. Partitioned areas for a control room, maintenance shop, locker room, shower, toilets and lunchroom are provided. Summer season comfort cooling is provided in all of these areas except the maintenance shop.

The costs to produce steam were determined for a steam plant with and without redundancy, or backup. The capital and annual costs are summarized in Table V-3. Also included is the estimated processing costs which would be required to prepare the waste for use in the boilers. These processing costs were developed in Part IV of this report. A detailed breakdown of the heating and power plant costs is included in Appendix D of this report.

TABLE V-3

STEAM PLANT COST SUMMARY

Capital Cost

Item	Cost Without Backup	Cost With Backup
Site Work and Utilities	$ 150,000	$ 170,000
Buildings & Foundations	1,100,000	1,110,000
Electrical, Mechanical & Spare Parts	650,000	1,000,000
Major Equipment & Auxiliaries	2,210,000	3,680,000
Contingency	595,000	905,000
Engineering and Contingencies	280,000	420,000
Total Heating Plant Cost	$4,985,000	$7,275,000
Processing Plant Cost	2,823,000	2,823,000
Total Project Cost	$7,808,000	$10,098,000

Annual Cost

Item	Cost	Cost
Maintenance	$ 90,000	$ 150,000
Labor	281,000	281,000
Water & Treatment Cost (For a system with condensate return)	35,000	35,000
Coal	6,000	6,000
Amortized Capital Cost (20 years @ 7.5%)	489,000	713,000
Processing Plant Cost	$1,471,000	$1,755,000
Approximate Cost of Steam (Dollars/1000 lbs. steam)	$3.20	$3.75

As the table shows, the total capital expenditure required for this alternative varies from approximately \$7.8 million to \$10.0 million depending upon if a redundant system is necessary. The table also shows the total annual cost for each alternative. The annual costs include labor, operation, maintenance and amortization of the capital expenditure. The boiler and processing plants were amortized using a 7.5 percent interest rate for a 20 year period. As shown, the cost to produce the steam would vary from \$3.20 to \$3.75 per thousand pounds depending upon the system. It should be noted that this is a general cost and does not include several of the cost factors which would be incurred in a specific situation. Total system costs will be determined for each specific market situation in the state as they are investigated. These specific costs will be summarized in the regional management plans.

3. <u>Electrical Generation Requirements & Costs.</u> Included in this alternative is the major equipment necessary to generate electricity from solid waste. The boiler for this facility has the capability of burning 225 tons per day of solid primary fuel. Because of the high pressure conditions required for power generation more Btu's are required to generate each pound of steam, therefore the pound per hour output from this boiler is less than that obtained from the steam plant alternative. The boiler has the capacity to deliver 60,000 pph of 800 psig, 750° F steam when fired with 100% RDF. Generally, the boiler auxiliary equipment is identical to that noted in the steam plant for heating or processing section. To obtain these steam conditions, a superheater is required.

A 6000 KW condensing automatic extraction steam turbine generator is included in this facility and is in the same building as the boiler. This unit is rated for throttle steam conditions of 800 psig, 750° F. For this facility a turbine exhaust surface condenser is required in the steam cycle. Other required equipment includes a cooling tower and transformer equipment. Figure V-2 shows a schematic of the steam thermal cycle of an electrical generating system fired with solid waste.

The capital and annual cost to generate electricity were determined for: (1) an electrical generating plant with no back-up boiler, and (2) an electrical generating plant with back-up boilers and turbine. The capital and annual costs for these alternatives are summarized in Table V-4. Also included in the table is the processing plant capital and annual costs. As shown, the capital expenditures required to generate electricity from solid waste would vary from \$11.0 million to \$14.7 million dollars depending on the need for back-up boilers and turbines.

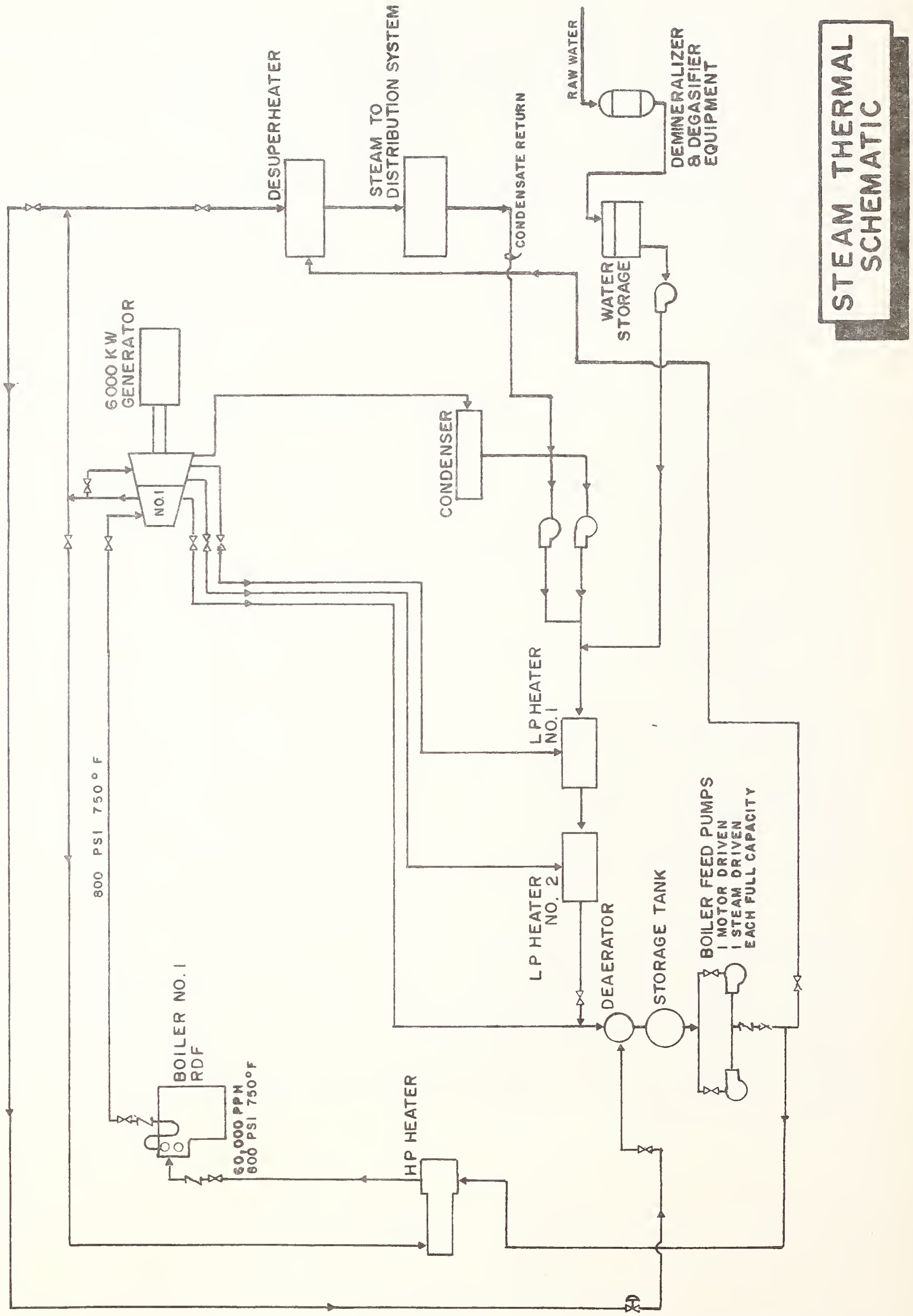

STEAM THERMAL SCHEMATIC
DESUPERHEATER
STEAM TO DISTRIBUTION SYSTEM
CONDENSATE RETURN
RAW WATER
DEMINERALIZER & DEGASIFIER EQUIPMENT
WATER STORAGE
6000 KW GENERATOR
NO. 1
CONDENSER
LP HEATER NO. 1
LP HEATER NO. 2
800 PSI 750° F
BOILER NO. 1 RDF
60,000 PPH 800 PSI 750°F
HP HEATER
DEAERATOR
STORAGE TANK
BOILER FEED PUMPS
1 MOTOR DRIVEN
1 STEAM DRIVEN
EACH FULL CAPACITY

FIGURE V - 2

TABLE V-4

ELECTRICAL GENERATION PLANT

COST SUMMARY

Capital Cost

Item	Cost Without Backup	Cost With Backup
Site Work & Utilities	$ 275,000	$ 260,000
Buildings & Foundations	1,800,000	1,900,000
Electrical, Mechanical and Spare Parts	1,200,000	1,500,000
Major Equipment & Auxiliaries	3,480,000	6,020,000
Contingency	1,020,000	1,476,000
Engineering and Contingencies	444,000	671,000
Total Generating Plant Cost	$ 8,219,000	$11,827,000
Processing Plant Cost	2,823,000	2,823,000
Total Project Cost	$11,042,000	$14,650,000

Annual Cost

Item	Cost	Cost
Maintenance	$ 100,000	$ 180,000
Labor	281,000	362,000
Water & Treatment Cost (For a system with condensate return)	35,000	35,000
Coal	6,000	6,000
Amortized Capital Cost (from above)	806,000	1,160,000
Processing Plant Cost	570,000	570,000
Total Annual Cost	$ 1,798,000	$ 2,313,000

C. ANALYSIS OF THE PYROLYSIS ALTERNATIVE

1. General. Pyrolysis systems include a wide range of innovative concepts, all of which utilize a pyrolysis process in one form or another in their energy conversion system. Pyrolysis is a process whereby organic materials are heated in the absence of oxygen to produce a gaseous or liquid product and a solid, carbon-rich residue. There is no question that pyrolysis is technically proven. Mankind has been pyrolyzing coal for hundreds of years to produce coke. He has been pyrolyzing wood for thousands of years to produce charcoal. Some decades ago, the process was adapted to produce petroleum coke. In recent years, there has been much publicity associated with adapting this age-old process to energy recovery from solid wastes. Millions of dollars have been spent to develop innovative new techniques for accomplishing this same process.

The objective of pyrolysis is to produce two fractions, one of which is a gaseous or liquid product that is high in energy value and the other product being free carbon, sometimes called carbonaceous char, mixed with ash and inerts. The characterization of the liquid or gaseous products is generally a function of the pyrolysis reaction itself, primarily the temperature and speed of the reaction as well as the rapidity with which the pyrolysis products are quenched to stop the pyrolytic reaction. Another factor affecting the characterization is the presence of other inert gas diluents such as nitrogen or carbon dioxide; however, since the feedstock material is predominantly cellulose, the pyrolytic products will be some form of a carbon-hydrogen-oxygen mixture. Generally, this will take the form of a methane-like product, some carbon monoxide, as well as some free hydrogen.

In all cases, the solid wastes feedstock is fed continuously into the pyrolytic reactor, and heat is supplied externally to drive the reaction. It is interesting to note that the wood and coal pyrolysis reactors which have operated successfully for many years do not incorporate a continuous-feed process, but rather are batch processes. This basic factor may be quite significant in assessing the rather consistent lack of outstanding success shown to date in refuse pyrolysis systems. The pyrolytic gases or liquids which are evolved are collected, drawn off of the reactor, quenched, and stored or combusted in a nearby combustion chamber. There have been many proposals to utilize these pyrolysis products as fuel for power plants, etc., as well as burning the products on site to produce steam, which might be used by a public utility or an industrial user. Some other variations include the burning of pyrolysis products in a gas turbine or internal combustion engine adjacent to the pyrolysis facility and producing electric power which, in turn, would be sold to some buyer. Other interesting proposals include transforming the pyrolysis gases into other more useful chemical products such as methanol, ethanol, benzene, and ammonia.

The primary advantages of a pyrolysis system are that the refuse can be transformed into gaseous or liquid fuel products which can be utilized by a

wider variety of buyers than a solid refuse derived fuel product. The limitations of the process should be clearly recognized: first, while the pyrolysis of cellulosic products is clearly technically feasible, no applications of this technology to the solid wastes field have been adequately demonsrated on a full-scale basis as of this date. Thus, the process remains developmental at this point, and the degree of success of a 300 ton per day facility within the next five years is problematical.

The principal applications for pyrolysis systems would be in those locations where the only practical form of energy recovery would be to produce a gaseous or liquid fuel product from the solid wastes. A necessary prerequisite for this installation would be a thoroughly confirmed, reliable buyer for the evolved products, willing to pay the premium price necessary to produce this premium fuel. The process economics would have to be carefully scrutinized and the risks associated with the unproven systems would have to be translated into the system economics. A thorough evaluation of the potential environmental impacts would also be inherent in this application.

2. Pyrolysis Operating Criteria and Costs. After analyzing the various pyrolysis systems being marketed, it was determined that the Union Carbide Purox System is presently the most applicable for the market situations in Montana. The Union Carbide process uses oxygen to develop a clean fuel gas. The gas has a heating value of about 300 Btu's per cubic foot. This fuel can be used as a supplement in most types of natural gas furnaces. This process requires pre-shredding and ferrous separation prior to introducing the solid waste into the pyrolysis unit. The volume reduction of the solid waste is 97 percent. Union Carbide has a 200 ton per day plant at South Charleston, West Virginia.

Union Carbide's marketing approach includes an operating contract and sharing in the revenues generated by the system. If satisfactory performance is attained, Union Carbide would negotiate a long-term operating contract with the owner of the facility. If the Purox system does not meet warranted performance, Union Carbide would be liable up to a mutually agreeable maximum for the modifications necessary to achieve warranted performance. Union Carbide would provide labor, supervision, and management of the pyrolysis system for a fixed fee contract with appropriate escalators to accommodate changing labor costs.

There are two basic facility costs included in the overall pyrolysis system; (1) the front-end processing facility, and (2) the Purox pyrolysis unit. For this application it was determined that the solid waste should be shredded and the ferrous metals extracted prior to pyrolysis. A detailed analysis of the preliminary processing site and equipment requirements and costs are included in Part IV of this report. A site plan of the processing facility is shown in Figure IV-1.

As discussed previously in this chapter, approximately 300 tons of refuse would be an average accumulation of waste in any one location in the state. Therefore, cost estimates and equipment and building requirements were determined for a 350 ton per day pyrolysis system. Using the Union Carbide pyrolysis system, this required one Purox 350 ton per day Module. The one module system has a maximum, nominal, and minimum capacity of 350 TPD, 300 TPD, 250 TPD respectively, based on a continuous operation of approximately 350 days a year.

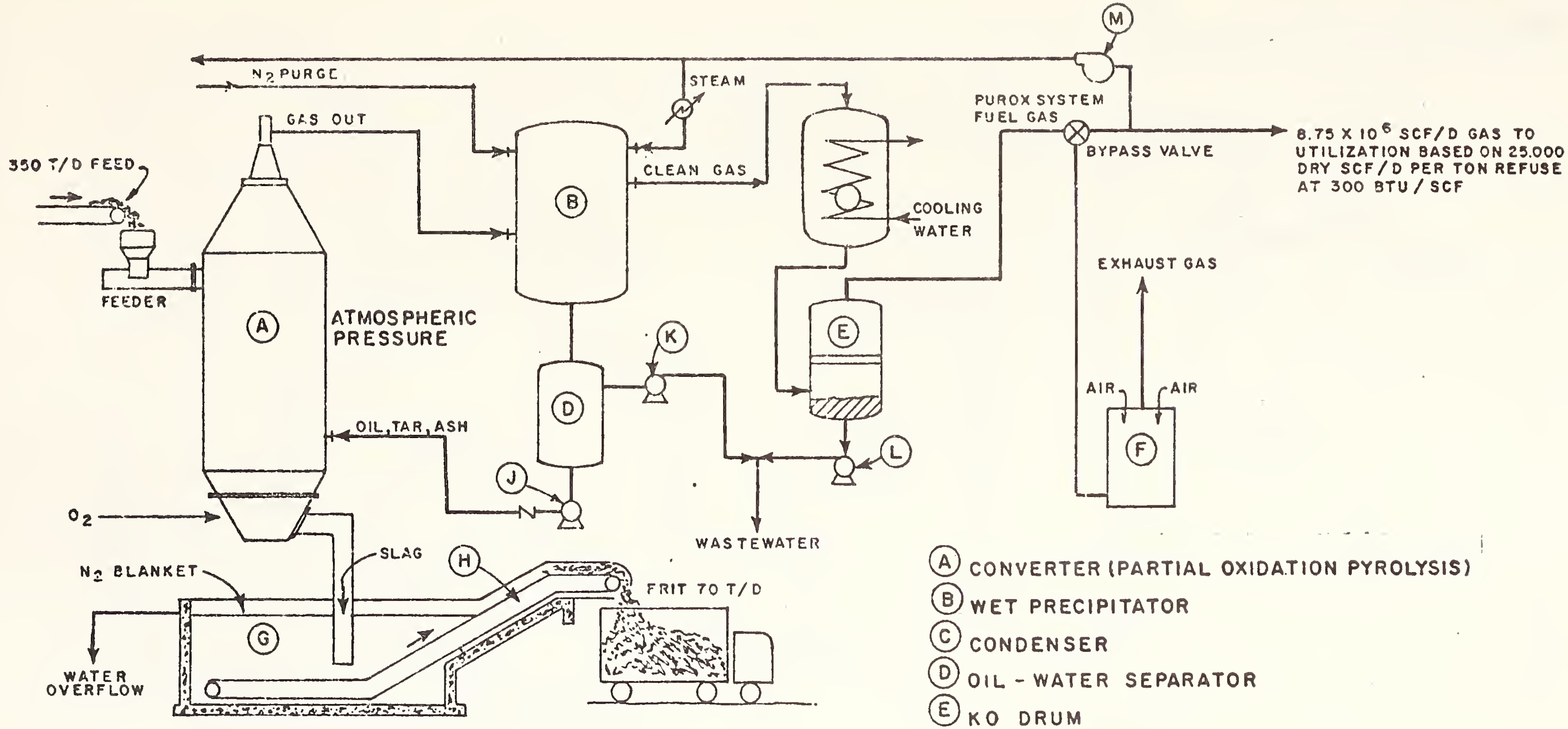
Included in the following paragraphs is a brief discussion of the operation procedure which would be followed for this alternative. The shredded refuse is transported mechanically to a feed lock system that injects the material into the top of a vertical shaft reactor. The feed lock effectively prevents the escape of fuel gas from the reactor. A limited quantity of oxygen is injected into the combustion zone at the bottom of the furnace where it reacts with carbon char residue from the pyrolysis zone above it. The molten residue continuously overflows from the reactor hearth into a water quench tank. The residue is mechanically converted into a dump truck for disposal or utilization. Hot gas formed from the oxygen carbon char reaction rises through the descending waste column. The pyrolyzed gas produced by the system exits the reactor at a relatively low temperature (200° F) to the gas cleaning system.

The gas cleaning system consists of a recirculating water scrubber and an electrostatic precipitator. Contaminates such as liquid hydrocarbons and entrained solids are separated from the scrubber water and recycled to the reactor. After cleaning, the gas product is passed through a condenser. Water extract is treated in an activated sludge system and discharged to a domestic sewer at approximately a 200-250 mg/l biochemical oxygen demand (BOD) loading. The wastewater produced averaged 80 gallons per ton of refuse.

Support facilities required for the Purox system include an oxygen generation unit or source of oxygen supply, a gas compression unit, and a wastewater treatment unit. A 350 ton per day Purox system requires the installation or availability of approximately 80 tons per day of pure oxygen. Wastewater produced by the system requires treatment before discharge to the sewer system. Gas compression is also required. Normally the Purox gas will be compressed to approximately 35-40 psig.

A flow schematic for the Purox system is shown in Figure V-3. A general site plan of the pyrolysis system is shown in Figure V-4. The site plan depicts the preliminary processing facility, Purox pyrolysis unit and the support facilities and equipment required.

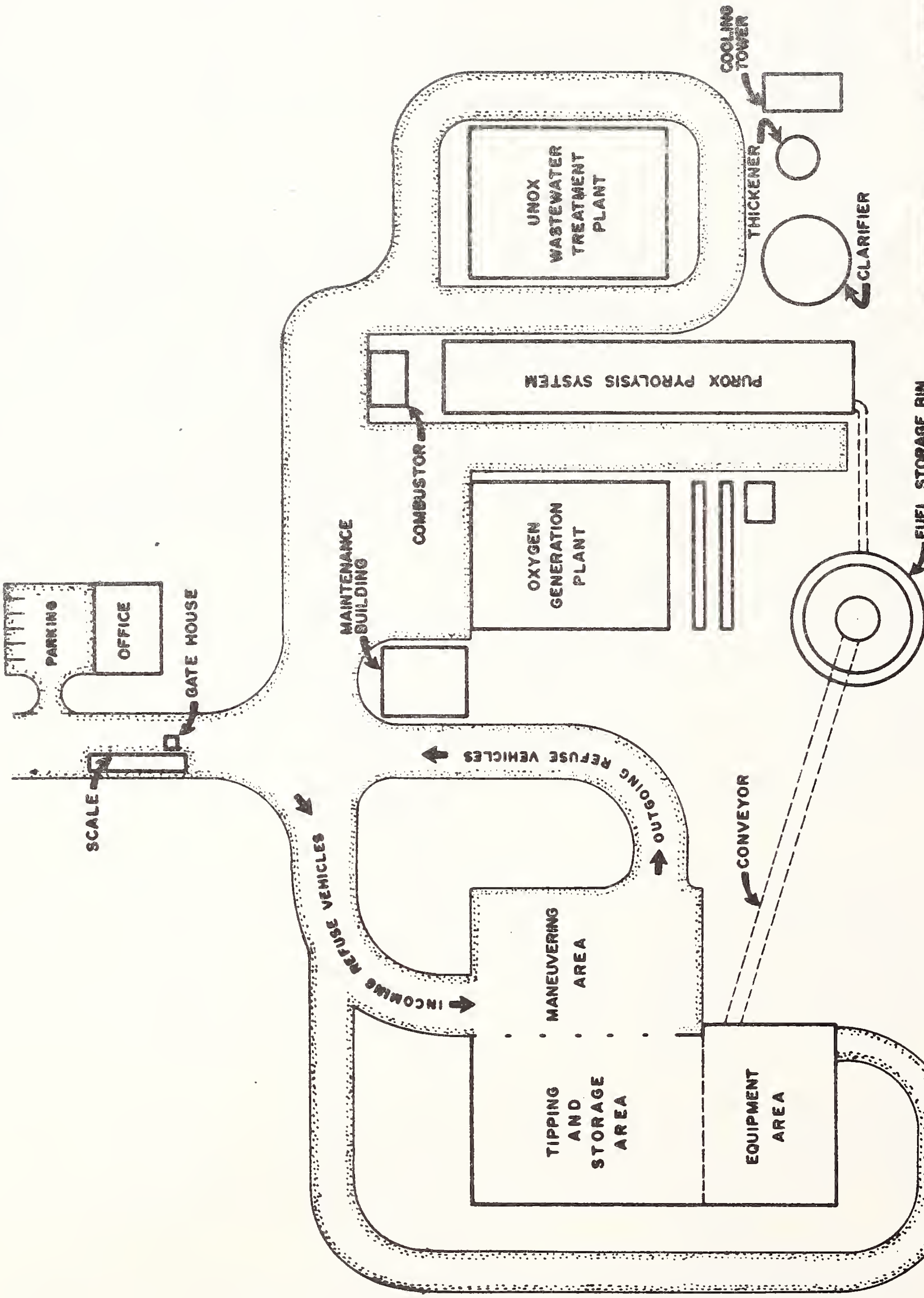
The capital and annual operating costs for the complete pyrolysis system are summarized in Table V-5. A detailed breakdown of the costs is listed in Appendix D of this report. As shown, the total project capital cost is



A CONVERTER (PARTIAL OXIDATION PYROLYSIS)
B WET PRECIPITATOR
C CONDENSER
D OIL - WATER SEPARATOR
E KO DRUM
F FLARE COMBUSTOR
G QUENCH TANK
H FRIT CONVEYOR
J OIL PUMP
K WASTEWATER PUMP
L CONDENSATE PUMP
M GAS BLOWER

PUROX SIMPLIFIED FLOW SCHEMETIC

FIGURE V - 3



PYROLYSIS SYSTEM SITE PLAN

FIGURE V - 4

TABLE V-5

PYROLYSIS SYSTEM COST SUMMARY

Capital Costs

Item	Cost
350 TPD Module	
Converter	$ 3,650,000
Oxygen Plant	1,920,000
Wastewater Treatment	448,000
Site Work	100,000
Installation (includes Engineering, Permits, Legal and Insurance)	2,900,000
Contingency	1,155,000
Total Purox Module & Accessories Cost	$10,173,000
Total Processing Plant Cost	2,171,000
Total Project Cost	$12,344,000

Annual Cost

Tons Per Day (7 day basis)	250 TPD	300 TPD	350 TPD
Item	Cost		
Operating Fee	$1,100,000	$1,150,000	$1,250,000
Electrical Power	212,000	252,000	293,000
Maintenance	215,000	215,000	215,000
Other Utilities	56,000	67,000	78,000
Amortization of Capital	$ 998,000	$ 998,000	$ 998,000
Processing Plant Cost	$ 515,000	$ 560,000	$ 650,000
Total Annual Cost For Project	$3,096,000	$3,242,000	$3,484,000
Cost per Ton	$34.02	$30.01	$27.22

approximately $12 million. This cost includes the processing facility, the storage of the processed material, and the Purox pyrolysis module and its required accessories.

The annual costs were determined for the minimum, nominal and maximum quantities of waste which could be processed through the system. As shown, the unit cost to generate the low Btu gas utilizing the Union Carbide Pyrolysis System ranges from $27 to $34 per ton depending upon the throughput of the system. These costs are considerably higher than the unit costs required for other resource recovery alternatives. Based on these costs, for the system to be economical, a revenue of $4 - $5 per million Btus would be required from the marketed low Btu gas which is produced from the system. This compares to the present cost of approximately $1.30 - $1.60 per million Btus which is being paid by the major industries in the state for natural gas. Based on the high costs of the pyrolysis alternative, it is not considered to be a viable solid waste utilization and disposal alternative in Montana at the present time, and will not be further investigated for this project.

D. ANALYSIS OF THE COMPOSTING ALTERNATIVE

1. General. This alternative involves the conversion of the organic portion of solid waste into usable products through decomposition by the use of aerobic microorganisms. There are several composting systems presently being marketed in the United States. Each system is similar in that the final product is a humus type material which can be utilized as a soil conditioner. To prepare solid waste so that it can be utilized as a soil conditioner, the metals, glass, plastic and other inorganic materials must be removed regardless of the system utilized. This requires that the waste be subjected to a separation and shredding process similar to that required when waste is utilized as a fuel in boilers.

After a thorough investigation was made of the various composting systems available and the marketability of the resultant product in the state, it was determined that two basic composting applications are potentially viable in the State of Montana; (1) the conversion of solid waste into a commercial fertilizer by aerobic digestion, and (2) the use of processed solid waste as a soil conditioner to replace stripped topsoil. Included in the following paragraphs is a brief description of the requirements, advantages, disadvantages, and costs of each potential application.

2. Application in Montana

a. Commercial Fertilizer. To determine applicable operating requirements and costs for this alternative, six systems presently being marketed in the United States were analyzed. It was determined that all the processes are similar, both in concept and in the degree of material preparation prior to composting. Several of the composting system manufacturers are presently demonstrating their system in the United States. Others have been attempted and are presently not operating, primarily due to poor economics rather than technical and design problems. It was determined that the "Eweson Process," which has been demonstrated in several cities in the United States, has the best potential for application in Montana. There are three basic steps involved in the process: (1) preliminary processing, (2) digestion, and (3) curing. Summarized herein is a description of the procedure involved in obtaining a salable soil conditioner product from solid waste.

Initially, the solid waste must be processed to remove the inorganic materials from the waste. These materials, which include the metals, glass, sand and grit, are either sold or landfilled. The required process is similar to the process involved in obtaining a fuel from waste which can be utilized in stoker fired boilers. The process which is utilized includes 1 stage of shredding, magnetic separation and air classification. A detailed layout of a processing facility which is required is shown in Figure IV-2.

After the waste has been processed, the organic portion is introduced into a digestion process. The digesters required in the "Eweson Process" are of

the aerobic type. The process requires that the refuse have a moisture content of 55 percent and have a carbon to nitrogen ratio of 30:1. Typically, municipal solid waste has a moisture content of 25-40 percent and a carbon nitrogen ratio of 45:1. Therefore moisture and nitrogen must be added to the waste during the digestion process. One method to increase the moisture and nitrogen content of the waste is to add sewage sludge to the waste. Sewage sludge typically has a high moisture and nitrogen content but still may not be able to supply the total nitrogen requirements. The best method of fulfilling the nitrogen requirements may be to utilize commercial fertilizer.

After the waste has been digested, the material is "green" and must be cured. The most applicable method to cure the digested material is to place the material in windrows. The material must be windrowed for approximately 30 days. At the end of the 30 day period the material is available for use as a soil conditioner.

A typical site layout of the required facilities to obtain a salable soil conditioner from solid waste is shown in Figure V-5. Included in the layout is a typical processing plant and the digester and storage area. As the figure shows, a large area is required for the system. The actual land requirements will depend upon the quantity of solid waste processed. The capital and annual costs for this compost process are summarized in Table V-6. Included are capital and operating costs for the processing plant, aerobic digesters and the curing area. As shown, the capital investment of the project would be approximately $15.6 million dollars.

To determine the viability of this alternative, the advantages and disadvantages of this system were compared to utilizing solid waste as an energy source. One extreme disadvantage of this composting alternative is economics. The capital costs of composting are approximately 5 times higher and the annual operating costs are approximately 4 times higher than if solid waste is utilized as an energy source. The second disadvantage is the marketability of the composted waste. Throughout the state there has been little indication of the potential to obtain long term contracts for the sale of the composted material. There have, however, been several industries in the state which have indicated interest in purchasing solid waste as an energy source. To finance either project, long term contracts for the purchase of the particular product produced is essential. Based on these major disadvantages, the alternative of producing a commercial fertilizer from solid waste is not favorable at this time. Therefore this alternative will not be further evaluated as a primary solid waste utilization and disposal alternative for this project.

b. Soil Conditioner. The alternative of tilling solid waste into the soil to obtain a more nutrient rich soil has been practiced for several years in the United States. The major problem through the years with this practice has been economics. Before solid waste can be utilized as a soil conditioner, the inorganic, inert materials must be separated from the humus like organic material. The material prior to tilling into the soil must also be reduced to a homogeneous size, preferably a 2 to 6 inch nominal size.

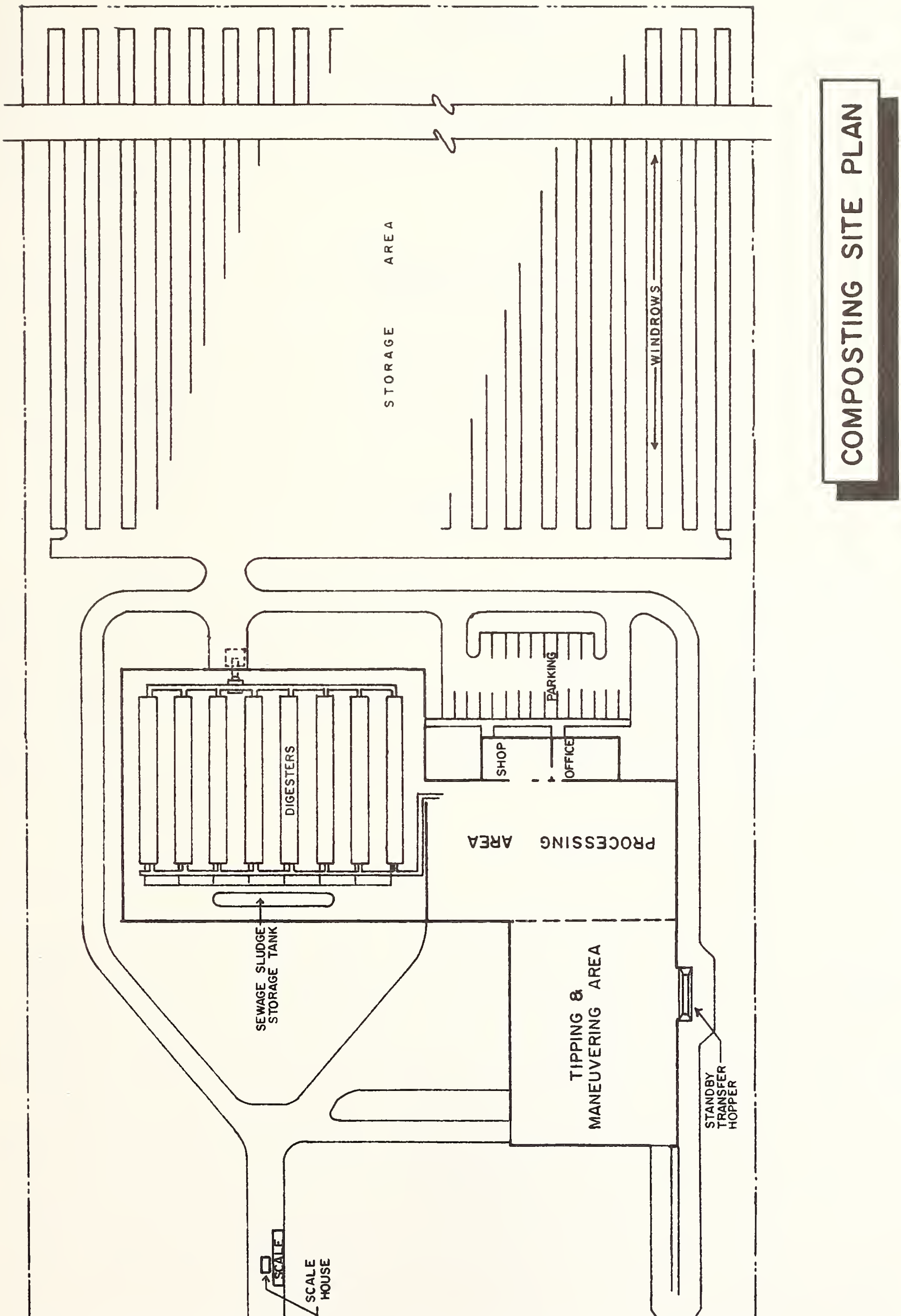

COMPOSTING SITE PLAN
STORAGE AREA
WINDROWS
PARKING
SHOP
OFFICE
DIGESTERS
PROCESSING AREA
SEWAGE SLUDGE STORAGE TANK
TIPPING & MANEUVERING AREA
STANDBY TRANSFER HOPPER
SCALE
SCALE HOUSE

FIGURE V - 5

TABLE V-6

COMPOSTING COST SUMMARY

Capital Cost

Item	Cost
Site Work	$ 320,000
Buildings (For Processing & Digesters)	2,084,000
Electrical, Mechanical & Spare Parts	3,317,000
Major Equipment	7,367,000
On Site Rolling Equipment	108,000
Engineering, Financing, Legal, Permits Insurance, Contingency	2,442,000
Total Project	$15,638,000

Annual Cost*

Item	Cost
Site and Building Maint.	$ 111,000
Mechanical and Electrical	190,000
Equipment Maint.	308,000
Supplies and Chemicals	179,000
Labor	336,000
Amortized Capital Cost (20 years @ 7.5%)	1,534,000
Total Annual Cost	$ 2,658,000

*costs are based on processing 300 ton per day of refuse 5 days per week.

Basically, the process required to prepare solid waste for use as a soil conditioner is very similar to the process which prepares solid waste for use as a fuel in a suspension type boiler. This process involves two stages of shredding for material size reduction and air classification to separate the organic and inorganic materials. In Part Four of this report a detailed site and equipment layout and cost estimate were developed for this type process. Figure IV-4 and Table IV-5 depict a layout and cost summary respectively for this waste processing mode. As the table indicates, the capital cost to prepare a waste for utilization as a soil conditioner is approximately $5.2 million. If approximately 250 tons per day of waste were processed, the unit processing cost per ton would be $13.67. Because of the high processing costs to prepare waste for use as a soil conditioner, it is imperative that revenues be obtained for the organic fraction which is utilized to make the alternative economically comparable with other disposal and/or utilization alternatives.

The situation in Montana which is most applicable for this alternative is the areas where coal is being strip mined. To strip mine coal the initial step is to strip and stockpile the topsoil. After the coal has been mined, the overburden and topsoil are replaced and vegetation is permitted to grow. Firms who are presently operating strip mines in Montana have indicated that the average cost of stripping, stockpiling and replacing topsoil is approximately $400 per acre.

Through an on-going study conducted at Montana State University, it has been determined that tilling processed solid waste into the overburden has resulted in the same or better plant growth than when topsoil is replaced and the growth is moderately fertilized. If this alternative is implemented by the firms presently operating strip mines in the state, the reclaiming of topsoil would not be required and thus a $400 revenue per acre could be realized. Through tests it has been determined that a depth of approximately 6 inches of waste is sufficient when utilized as a soil conditioner. Based on a refuse density of 300 lbs. per cubic yard, one acre of land would utilize approximately 121 tons of refuse. Based on a savings of $400 per acre, a net revenue of $3.30 per ton could be realized.

An analysis of the costs involved to process solid waste such that it can be utilized as a soil conditioner ($13.67 per ton) and the revenues which can be obtained ($3.30 per ton) indicates that this alternative cannot economically be jsutified. Other economic factors such as transportation and tilling costs which would be incurred and intangible factors which relate to the storage and handling problems of the processed refuse all add to the disadvantages of implementing this alternative. Based on these disadvantages, the alternative of utilizing solid waste as a soil conditioner at this time is not favorable.

APPENDIX A

CAPITAL AND OPERATING CRITERIA
FOR
SANITARY LANDFILLS

APPENDIX A

The purpose of this appendix is to: (1) outline the capital and operational criteria, and (2) describe the basis for the capital and operational costs for the various size sanitary landfills which were analyzed and determined applicable in the State of Montana. The criteria used for this project was determined through interviews with several personnel which are familiar with solid waste disposal both in the state and on a national level. The State Solid Waste Bureau also recommended certain operational criteria which they felt was appropriate in order for solid waste to be properly disposed of in the state. A copy of the operational criteria the State Solid Waste Bureau determined applicable is included in this appendix.

1. Capital Requirements

a. Site Requirements. For each of the various sanitary landfills analyzed, the required land, buildings and site improvements were determined. The land requirements were based on a landfill depth of 35 feet with a fifteen year life. Based on this assumption it was determined that the smaller landfill would require a minimum of 4 acres where the larger landfills would utilize approximately 50-80 acres in a fifteen year period. It was assumed that for all landfills receiving 2 to 200 tons per week of waste a small pole barn would be required to house the equipment. For the landfills larger than 200 tons per week it was determined that a more sophisticated building with a small shop area would be required. It was also assumed that all landfills receiving 500 tons per week or more would require a gate house and scale. It was assumed that all landfills would require a minimal cost fence to restrict entrance and that each site would require a minimum of 300 feet of on-site improved gravel roads. Each site larger than 50 tons per week would also require on-site utilities.

b. Equipment Requirements. In determining the landfill design criteria an important item is the hours of operation necessary to handle the specific quantity of waste expected. The equipment necessary to operate a sanitary landfill is a major source of the capital cost of the facility. For this project it was assumed that all equipment utilized at a landfill would be purchased. For landfills receiving 350 tons per week or less a track type front loader was determined to be applicable for moving, compacting and covering the waste with soil. With the exception of the landfills receiving approximately 350 tons per week, it was determined applicable to purchase a used front loader. For landfills receiving greater than 350 tons per week of waste it was determined necessary to purchase and utilize a new D-8 dozer. For landfills receiving 1000 tons per week or greater, it was anticipated that a four wheel compactor would also be required.

At each landfill site regardless of the size, an area or trench must be excavated to place the waste in. The soil from the excavation can then also be utilized as cover material. Due to the economy of scale it was assumed for

all landfills receiving less than 500 tons per week of waste, that the trench or area excavation would be subcontracted periodically to an earth moving contractor.

The cost for the excavation for these size landfills was estimated by assigning a unit cost per cubic yard for the required volume of material required to be excavated. For landfills receiving 500 tons per week or greater it was assumed appropriate for each landfill to purchase a used scraper and perform the excavation and stockpiling of soil as part of the daily operating procedures. It was assumed that the used scraper would be operated by use of the D-8 dozer which would be on-site.

In addition to the equipment used to cover the waste and excavate soil, it was also determined applicable for the landfills receiving 500 tons per week or greater to provide a water truck and utility vehicle. To provide good access to the landfill site, the cost to rent a grader periodically was also included.

c. Capital Cost Summary. Summarized in Table A-1 is a breakdown of the site and equipment requirements for each of the various size landfills which were analyzed. The unit costs which were utilized to determine the capital costs for each size landfill are also illustrated in the table.

2. Operational Requirements

a. Site and Equipment Operational Criteria. A major cost associated with operating a sanitary landfill is the operational costs of the equipment. To develop the operational costs of the various types of equipment required to properly operate a sanitary landfill, it was necessary to determine: (1) the approximate number of hours each type of equipment would be operating and for each size landfill, (2) the approximate cost per hour to operate each type of equipment. Table A-2 summarizes the approximate cost per hour to operate the various types of equipment. This information was obtained from the Caterpillar Performance Handbook.

Department of Health and Environmental Sciences
STATE OF MONTANA HELENA, MONTANA 59601

Solid Waste Management Bureau
Helena, Montana 59601
Telephone: (406) 449-2821

A. C. Knight, M.D.
Acting Director

February 26, 1976

Mr. Barry Damschen
Henningson, Durham and Richardson, Inc.
2225 11th Avenue
Helena, Montana 59601

Dear Mr. Damschen:

As per your request, you will find enclosed the operational criteria required or recommended by this bureau for sanitary landfills and transfer facilities. You will notice that items 5 and 6 are recommendations rather than requirements. While not required, this bureau strongly recommends that the items be followed to insure a properly operated sanitary landfill.

The enclosed operating criteria are for a "standard" sanitary landfill. However, it is recognized by this bureau that no standardized model can be uniformly applied statewide but can be of value if developed specifically for each planning district.

I hope this information is satisfactory for your planning efforts.

Sincerely,

Terrence D. Carmody

TERRENCE D. CARMODY, CHIEF
Solid Waste Management Bureau
Environmental Sciences Division

TDC:BP:ao

Enclosure

OPERATIONAL CRITERIA

Landfills - All Sizes

1. Fencing to the degree that it will control access.
2. If the site is located within 1,000 feet of the federal interstate or primary highway system, it will be screened.
3. The site will be open a sufficient amount of time to adequately serve the community; and each day that the site is open, the solid waste will be covered.
4. It is recommended that each site be open a minimum of two days a week and that each site will require a minimum of two hours of maintenance per operating day.
5. For a site serving a population of 4,000 and greater, a gate keeper is recommended and record keeping as to quantities of solid waste received. For communities over 40,000, it is recommended that the site maintain a scale.
6. Engineering design is strongly recommended. Soil investigations are required and test wells are required only in those areas that indicate a need for it.
7. A six inch daily cover and a two-foot final cover is required.
8. For shredded refuse, a final cover of two feet will be necessary; no daily cover will be necessary.

Transfer Stations

Requirements for transfer stations will be the same as for landfills for items 1 through 6.

TABLE A-1

SANITARY LANDFILL CAPITAL COST CRITERIA

		Landfill Size (Tons Per Week)											
		2-8	10	30	50	100	200	350	500	750	1,000	1,500	2,000
	Unit	Contributing Population											
Item	Cost	200-800	1,000	2,400	4,000	6,000	10,000	17,500	25,000	37,500	50,000	75,000	100,000
Land	--	4 ac	4	4	4	6	10	18	25	35	45	75	95
Fencing	$1.30/ft	$ 1,650	$ 1,650	$ 1,650	$ 1,650	$ 2,045	$ 2,640	$ 3,540	$ 4,175	$ 4,950	$ 5,600	$ 7,230	$ 8,000
Roads	$8.00/ft	$ 300	$ 300	$ 300	$ 300	$ 300	$ 300	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000
Scale	$25,000	--	--	--	--	--	--	--	1	1	1	1	1
Bldgs.	Var.	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$ 9,000	$32,000	$ 32,000	$ 32,000	$ 36,000	$ 48,000	$ 48,000
Gate-house	$3,000	--	--	--	--	--	--	--	1	1	1	1	1
Misc. Utilities	Var.	--	--	--	--	$ 4,000	$ 4,000	$ 4,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000
Front Loader	Var.	$30,000	$40,000	$50,000	$60,000	$60,000	$60,000	$95,000	--	--	--	--	--
Dozer	Var.	--	--	--	--	--	--	--	$100,000	$132,000	$132,000	$132,000	$132,000
Compactor	$75,000	--	--	--	--	--	--	--	--	--	1	1	1
Excavation													
Contract	$1.30/yd	$500-1,000/yr	$ 1,300	$ 3,000	$ 4,000	$ 5,500	$ 7,000	$ 8,000	--	--	--	--	--
Prch.	$15,000	--	--	--	--	--	--	--	1	1	1	1	1
Wtr. Trk.	$ 5,000	--	--	--	--	--	--	--	--	1	1	1	1
Utility Vehicle	$ 5,000	--	--	--	--	--	--	--	1	1	1	1	1

TABLE A-2

EQUIPMENT OPERATING COST

(Cost Per Hour)

Type Vehicle	*Fuel Consumption (Gal/Hr)	*Fuel Consumption (Costs/Hr)	Approximate Hourly Cost in Use of Lub., Oils, Grease, Etc. Cost/Hour	Cost of Filters	Hourly Repair Costs	Insurance & Taxes	Total Cost/Hour
Grader	4.4	$1.98	$0.15	$0.55	$3.00	$1.50	$ 7.18
D-8 Dozer	10.4	$4.68	$0.30	$0.85	$8.65	$1.95	$16.43
Compactor	9.1	$4.09	$0.50	$0.62	$6.00	$1.13	$12.34
Water Truck	4.0	$2.00	$0.15	$0.25	$2.00	$0.50	$ 4.90
Scraper	--	--	$0.05	--	$1.05	$0.20	$ 1.30
Front Loader (Track Type)	5.0	$2.25	$0.20	$0.63	$4.05	$0.45	$ 7.58

*Costs are based on medium load factor use.

Source: Caterpillar Performance Handbook

The costs shown in Table A-2 are all inclusive except for the depreciation and labor costs. Depreciation costs for this type of equipment in most instances are determined by assuming a life of 10,000 hours per piece of equipment with a 40 percent resale. If depreciation is included in the operational costs shown in Table A-2, the costs associated with operating the three major types of equipment (excluding labor) are:

Front-end Track Type Loader	$14.00 per hour
D-8 Dozer	$25.25 per hour
Compactor	$17.35 per hour

Utilizing several sources of information (discussed in Part II) the hours required to operate the equipment for the various size landfills were determined. Table A-3 summarizes the estimated hours required to operate each type of equipment for the various size landfills. As the table indicates it was determined necessary for the landfills ranging from 2-50 tons per week to operate a front loader for a minimum of 2 hours for each day the landfill was open. It should be noted that the hours in which the use of a water truck, grader and utility vehicle are not shown in Table A-3 due to the unpredictability of determining when the services of each would be required. For estimating purposes, however, an annual cost was approximated and is depicted in Table A-3. It should also be noted that for the costs summarized in Part II of this report an emergency equipment operating fund was included. The primary purpose of this fund to take into account the cost to rent equipment manufacturers, it was determined that in a normal operating year an additional ten percent of the capital cost of the equipment used on-site would be spent on equipment rental due to down time. Therefore this additional ten percent has been included in the annual operating costs of those landfills receiving 100 tons per week of waste or more.

TABLE A-3

EQUIPMENT OPERATING REQUIREMENTS

Landfill Size (TPW)	Contributing Population	Days/Wk Open	Hours Per Week Operated: Front Loader	Dozer	Scraper	Compactor	Dollars Per Year: Utility Vehicle	Water Truck	Grader
2-50	2,000-4,000	2-5	4-10	--	contract	--	--	--	$ 700
100	6,000	5	15	--	contract	--	--	--	--
200	10,000	5	20	--	contract	--	--	--	--
350	17,500	5	30	--	contract	--	--	--	--
500	25,000	6	--	25	10	--	$400	--	--
750	37,500	6	--	30	10	--	$400	$350	$1,400
1,000	50,000	6	--	25	10	20	$500	$350	$1,400
1,500	75,000	6	--	50	25	40	$600	$500	$1,400
2,000	100,000	6	--	60	25	45	$600	$600	$1,400

b. <u>Labor Requirements.</u> In a landfill operation a large portion of the annual costs are for labor. Based on the operation of several well operated landfills throughout the state and country, the labor requirements for the various size landfills analyzed for this project were determined. For all landfills receiving 350 tons per week or less, it was assumed that the landfill would not have a gate attendant. For these situations it is likely that a city, county or refuse district employee would open the gate each day the landfill is open. The only labor requirements for these size landfills would be the equipment operator's time required to cover the waste at the end of each day. It was assumed that this individual would have other responsibilities and would therefore charge to the landfill operation costs only his actual time at the landfill. For all landfills receiving more than 350 tons per week of waste, it was assumed that a full time gate attendant would be on duty. For these size landfills it was assumed that a foreman would be included in the overall operation costs. The foreman would most likely also be used as a general public works foreman and therefore his entire 40 hour week would not be charged to the operation of the landfill.

Table A-4 depicts the estimated hours of labor which would be required to operate each size landfill. The labor requirements are divided by employee type.

TABLE A-4

LABOR REQUIREMENTS

Landfill Size	Contributing Population	Days/Wk Open	Hours per Week: Foreman	Operators	Gate-keeper	Laborers
2-50	200-4,000	2-5	--	8-20	--	--
100	6,000	5	--	25	--	--
200	10,000	5	--	30	--	--
350	17,500	5	10	40	--	--
500	25,000	6	10	40	48	20
750	37,500	6	20	60	48	20
1,000	50,000	6	20	80	48	40
1,500	75,000	6	20	100	60	40
2,000	100,000	6	24	120	60	40

To determine the labor costs, average labor rates presently being paid in Montana were used. Listed below are the labor rates which were determined to be applicable for this project. It was assumed that each employee would also receive 30 percent of his wage in benefits.

	Base Salary	Benefits + 30%	Total Rate
Foreman	$15,000/year	$4,500	$19,500/year
Equipment operator	$ 4.75/hr.	$ 1.43	$ 6.18/hr.
Laborer	$ 3.00/hr.	$ 0.90	$ 3.90/hr.
Gate Attendant	$ 2.30/hr.	$ 0.70	$ 3.00/hr.

APPENDIX B

CAPITAL AND OPERATING CRITERIA FOR TRANSFER STATIONS

APPENDIX B

The purpose of this appendix is to: (1) outline the capital and operational criteria, and (2) describe the basis for the capital and operational costs for the various size transfer stations. The criteria and costs used in this appendix were determined through: (1) interviews with several operators and designers of transfer stations presently operating in the country and (2) on-site inspections of several transfer stations now in existence.

1. Capital Requirements

a. Site Requirements. For each of the various sizes and types of transfer stations analyzed the necessary land, site work and utilities, and building requirements were determined. Basically, the site work for the non-compacted roll-off station consisted of construction of a retaining wall and concrete pad, preparation of a roadway and general landscaping. For the compactor type stations, each station was supplied with sanitary sewers, potable water and electricity in addition to the required roadways, ramps, retaining walls and fencing.

For each of the compaction type stations a gate house and control room was deemed necessary and for all stations receiving 500 tons per week or greater, a scale was also included. A metal housing was determined necessary to cover all transfer stations which utilize compaction equipment and for all stations receiving 100 tons per week or greater, it was determined applicable to include an enclosed tipping area.

b. Equipment Requirements. To operate stationary type compaction transfer stations very little equipment is necessary. For the compaction type stations which were not of the push pit variety, the only equipment required is the stationary compactor and transfer vehicle. For stations receiving 10-30 tons per week of waste, it was determined applicable to utilize a 40 cubic yard roll-off container to transport the compacted waste. For all stations receiving greater than 30 tons per week, a 65 cubic yard transfer trailer was determined most appropriate.

For the larger more sophisticated transfer stations, more equipment is required. For the transfer stations ranging in size from 250 through 750 tons per week a hydraulic ram (push pit) was used. For stations greater than 750 tons per week an additional push pit and compactor unit was determined necessary to give the station added capacity. The high frequency at which transfer vehicles are moved in and out of stations receiving greater than 500 tons per week can cause serious delays. Therefore it was determined necessary to utilize a vehicle which could maneuver empty and full transfer trailers into position at the appropriate time intervals. From past experience it was determined that a used tractor (trailer jockey) could perform this task quite effectively. Thus a trailer jockey has been included in the overall costs of transfer stations receiving 500 tons per week of waste or greater.

c. Capital Requirements Summary. Summarized in Table B-1 is a breakdown of the site and equipment requirements for each of the various size transfer stations which were analyzed. The unit costs which were utilized to determine the capital costs of each size station are also illustrated in the table. The capital costs used in this analysis are based on April, 1976 construction, equipment and materials cost.

2. Operational Requirements

a. Labor Requirements. The major expense incurred in operating a transfer station is the labor requirements. For transfer stations which direct dump into open top containers, it was assumed that no labor will be required for normal operation. A grader operator will be required periodically to repair roads and keep the ramp in proper condition. For transfer stations between 10 and 150 TPW, it was assumed that an equipment operator would not be required at the facility full time. With proper scheduling, a city or county employee or an individual who collects waste in this area and utilized the station could periodically activate the compactor. This arrangement would require only a small fraction of his time and would depend upon the local situation. For transfer stations receiving 150 TPW or more, an equipment operator would be required full time at the equipment controls. The equipment operator's primary task would be to activate the hydraulics on the push pit(s) and compactors.

For stations handling more than 500 tons per week a full time gate attendant for the hours the facility was open was included. For transfer stations handling 250 tons per week and greater, a foreman would be required to spend a portion of his time to insure a smooth and efficient operation. For transfer stations receiving 250 tons per week or greater a laborer would also be required to control traffic and keep the station clear of debris.

Table B-2 depicts the estimated hours of labor which would be required to operate each size transfer station. The labor requirements are divided by type employee.

TABLE B-2

LABOR REQUIREMENTS

Transfer Station Size (Tons/Wk)	Contributing Population	Hrs./Wk Open	Foreman	Equipment Operators	Gate-keeper	Laborers
10-30	1,000-2,400	40	--	6	--	--
50	4,000	40	--	8	--	--
100	6,000	40	--	20	--	--
150	7,500	40	--	40	--	--
250	12,500	48	10	40	--	20
500	25,000	48	20	48	48	40
750	50,000	48	20	48	48	40
1,500	75,000	48	20	48	48	80
2,000	100,000	48	24	48	48	80

TABLE B-1

TRANSFER STATION CAPITAL COST CRITERIA

	Unit	TPW	10-30	50	100	150	250	500	750	1,500	2,000
Item	Cost	Pop.	1,000-2,400	4,000	6,000	7,500	12,500	25,000	50,000	75,000	100,000
Misc. Utilities, etc.	Var.		$18,100	$18,000	$18,000	$18,000	$23,500	$23,500	$23,500	$40,700	$40,700
Scale	$25,000		--	--	--	--	--	1	1	1	1
Buildings											
receiving	$25/s.f.		--	--	600	600	2,400	2,400	2,400	4,800	4,800
compaction	$25/s.f.		150 s.f.	150	150	150	900	900	900	1,800	1,800
gate house	$30/s.f.		81 s.f.	81	81	81	81	200	200	200	200
Transfer Veh.											
container	$ 4,500		1	--	--	--	--	--	--	--	--
trailer	$22,500		--	1	1	1	1	1	1	2	2
Compactor	$27,500-$36,500		1	1	1	1	1	1	1	2	2
Push pit	$13,000		--	--	--	--	1	1	1	2	2
Tr. Jockey	$ 3,000		--	--	--	--	--	1	1	1	1

For transfer stations it was assumed that the same labor rates would apply as those determined applicable for sanitary landfills.

b. Equipment and Site Operational Requirements. To determine operating and maintenance costs for the compaction and push pit equipment, equipment manufacturers were contacted. The costs which were obtained were relatively the same in each instance. From the manufacturers it was determined that the operation and maintenance (O&M) costs for a stationary compactor is approximately $0.50 per ton of waste compacted. The O&M costs for a hydraulic ram are approximately $0.25 per ton. For each size transfer station these unit costs were applied (when applicable) directly to the quantity which was received at the station. To determine the cost to operate a trailer jockey, several tractor operators were contacted. It was determined that the cost to operate this vehicle would vary from $1,000 to $1,500 per year depending upon the hours it was utilized.

To determine the site and building operational costs for the various size transfer stations analyzed, operational costs of similar type stations in the Pacific Northwest were reviewed. From the information obtained it was determined that $0.40 per square foot per year is a reasonable estimate of the cost to operate and maintain a building similar to those which were determined applicable for this project. It was also determined that the site maintenance costs vary considerably depending upon the size of the transfer station. For this project it was estimated that the site maintenance costs would vary from $500 to $1,500 per year depending upon the size of the station.

APPENDIX C

CAPITAL AND OPERATING CRITERIA FOR PROCESSING FACILITIES

APPENDIX C

The purpose of this appendix is to describe the basis for the capital and operating costs that were summarized in Part Four of this report. This appendix is divided into two sections: (1) capital requirements, and (2) criteria used to develop annual operating and maintenance cost.

In the tables of this appendix, the alternatives analyzed are designated as follows: Alternative #1 - shred-landfill process; Alternative #2 - the pyrolysis feedstock process; Alternative #3 - the stoker fired refuse fuel process; and Alternative #4 - the suspension fired refuse fuel process.

1. Capital Requirements

a. Buildings. The buildings are constructed with a steel frame structural system, metal panel exterior walls, metal deck roof and reinforced concrete foundations and floors. The area requirements for each section of the four processing buildings is given in C-1. The table gives a description of the building area requirement and the unit cost associated with each area type.

TABLE C-1

BUILDING CAPITAL COST CRITERIA

Building Description	Unit Cost	Alt. #1	Alt. #2	Alt. #3	Alt. #4
Office	$30/s.f.	20'x45'	20'x45'	25'x45'	25'x30'
Scale House	$30/s.f.	4'x10'	5'x10'	5'x10'	5'x10'
Control Room	$30/s.f.	20'x45'	20'x45'	20'x45'	25'x35'
Receiving & Storage Area	$20/s.f.	80'x120'	80'x120'	80'x120'	100'x180'
Equipment Area	$30/s.f.	60'x70'	60'x70'	60'x120'	100'x180'

b. Equipment. Listed in Table C-2 is a breakdown of the criteria used to develop the capital cost of the equipment for each alternative. In addition to the unit costs of the various types of equipment, the table shows the numbers of each type of equipment required for each alternative.

TABLE C-2

EQUIPMENT REQUIREMENTS

Equipment Description	Unit Cost	Required Number of Units			
		Alt. #1	Alt. #2	Alt. #3	Alt. #4
Maintenance Crane	$ 30,000	1	1	1	1
Scale	$ 25,000	1	1	1	1
Shredder 50 TPH	$300,000	1	1	1	2
Magnetic Separator	$ 30,000	1	1	1	1
Air Classification Equipment	$250,000	0	0	1	1
Conveyors Infeed	$ 1,200/'	40'	40'	40'	80'
Primary Belt 4' Wide	$ 800/'	40'	40'	40'	210'
Ferrous Aluminum & Heavy Conveyors	$ 500/'	20'	20'	20'	180'
Fuel to Storage Bin	$ 1,000	0'	120'	120'	120'
Compactor	$ 30,000	1	0	0	0
Aluminum Separation Equipment	$500,000	0	0	0	1
Refuse Fuel Storage	$170,000	0	1	1	1
Rolling Equipment Description					
Front-End Loader	$ 30,000	1	1	1	1
Grounds Machine	$ 10,000	1	1	1	1
Dump Truck	$ 25,000	1	1	1	1

c. Other Capital Costs. General plant facilities were developed under two subgroups: (1) utilities which include yard lighting, sewer lines, water lines, gas lines, and telephone, and (2) site work, which includes drives and sidewalks, excavation and grading, landscaping, fencing and gates. Installation costs of the equipment were taken as a percent of the basic equipment capital cost. Twenty-five percent of the equipment cost was used. A contingency ranging from 10 to 20% of the equipment cost was added to the project construction cost. The reason for the range in the percent added for contingency is due to the relative stability and reliability of costs received from various equipment suppliers. The contingencies are not included in the costs shown in this appendix but are reflected in the costs summarized in Part Four.

To arrive at a total project cost, Owner's cost was added. Owner cost includes items such as engineering, legal, financing, permits and insurance. Engineering is included at 5% of the construction cost for each project. From past studies and experience it is the Consultant's general opinion that 2% should be added for legal and 1% for financing.

2. Operating and Maintenance Cost Criteria

a. Labor Requirements. The total cost of labor is summarized in the tables shown in the body of this report. Included in this appendix is the labor staffing requirements for each process. These requirements are tabulated in Table C-4. Table C-3 shows the labor rates which were used for this study. The rates were determined by analyzing the present labor rate schedule in several cities in the state. It was assumed that each employee would also receive 30 percent of his wage in benefits.

TABLE C-3

LABOR RATES

Job Title	Base Rate	Labor Cost (including 30% Benefits)
Foreman	$15,000	$19,500
Equipment Operator	$ 9,875	$12,840
Laborer	$ 6,230	$ 8,110
Mechanic	$ 9,875	$12,840
Gate Attendant	$ 4,780	$ 6,220

b. Building and Equipment Operation and Maintenance. Table C-5 shows the criteria used to develop building and equipment O&M

TABLE C-4

LABOR REQUIREMENTS
FOR PROCESSING PLANTS

	Alternative #1			Alternative #2			Alternative #3			Alternative #4		
JOB TITLE	125TPD	250TPD	400TPD	125TPD	250TPD	400TPD	125TPD	250TPD	400TPD	125TPD	250TPD	400TPD
Foreman	1/2	1/2	1	1/2	1/2	1	1/2	1	1	1/2	1	1
Equipment Operator	2	2	2	2	2	2	2	2	2	2	3	3
Laborer	1	1	2	1	1	2	2	2	2	2	2	3
Mechanical	0	1/2	1	0	1/2	1	0	1	2	1/2	1	2
Gate Attendant	1	1	1	1	1	1	1	1	1	1	1	1

TABLE G-5

OPERATION AND MAINTENANCE CRITERIA FOR PROCESSING PLANTS

ITEM	Alternative #1 125 TPD	Alternative #1 250 TPD	Alternative #1 400 TPD	Alternative #2 125 TPD	Alternative #2 250 TPD	Alternative #2 400 TPD	Alternative #3 125 TPD	Alternative #3 250 TPD	Alternative #3 400 TPD	Alternative #4 125 TPD	Alternative #4 250 TPD	Alternative #4 400 TPD
Shredder Maintenance	$ .50/Ton	$ .50/Ton	$ .50/Ton	$ .50/Ton	$ .50/Ton	$ .50/Ton	$ .50/Ton	$ .50/Ton	$ .50/Ton	$ .87/Ton	$ .87/Ton	$ .87/Ton
Electrical Power	$1.00/Ton	$1.00/Ton	$1.00/Ton	$1.00/Ton	$1.00/Ton	$1.00/Ton	$1.25/Ton	$1.25/Ton	$1.25/Ton	$1.75/Ton	$1.75/Ton	$1.75/Ton
Site Upkeep		5 Acres ($1,000/Acre/Yr.)			5 Acres ($1,000/Acre/Yr.)			5 Acres ($1,000/Acre/Yr.)			5 Acres ($1,000/Acre/Yr.)	
Building Heating, and Maintenance	17,600Ft^2	17,600Ft^2	17,600Ft^2	17,600Ft^2	17,600Ft^2 ($0.70 per Square Foot)	17,600Ft^2	19,625Ft^2	19,625Ft^2	19,625Ft^2	22,600Ft^2	22,600Ft^2	22,600Ft^2
Mechanical and Electrical Maintenance*	$12,800	$15,400	$18,400	$12,800	$15,400	$18,400	$21,200	$25,500	$30,000	$56,700	$68,000	$51,500

*Represents 4 percent of the equipment capital cost.

cost. The unit cost (dollars per ton) for shredder maintenance and electrical power was obtained from actual operating data as demonstrated at the Ames, Iowa resource recovery processing plant. Building and equipment maintenance costs were obtained from: (1) operating data at present solid waste processing plants, (2) utilizing present utility rates in the state, and (3) utilizing information supplied by equipment manufacturers.

APPENDIX D

CAPITAL AND OPERATING CRITERIA FOR UTILIZATION FACILITIES

APPENDIX D

In this appendix a breakdown and description is given for the capital cost of the equipment used in the steam and power plants. Table D-1 shows a breakdown of the capital cost of the steam and power plant's equipment. Staffing requirements and labor costs for the steam and power plants are listed in Tables D-2 and D-3 respectively. For this analysis, the following designation is used to describe the four steam and power facilities: (1) Alternative #1 - steam plant with one boiler; (2) Alternative #2 - steam plant with two boilers; (3) Alternative #3 - power plant with one boiler and one turbine; and (4) Alternative #4 - power plant with two boilers and two turbines.

A breakdown of the capital and operating costs for the composting alternatives are very similar to the stoker and suspension fired boiler processing alternatives and have not been duplicated in this appendix. The capital and operational information for the "Eweson" Digesting process was supplied by the manufacturer in the detail in which it is presented in Part Five.

TABLE D-1

CAPITAL COST FOR EQUIPMENT IN HEATING & POWER PLANTS

Equipment Description	Unit Cost	Alt. #1	Alt. #2	Alt. #3	Alt. #4
Boiler	$12.5/# of capacity	70,000 pph	2 @ 70,000 pph	60,000 pph	2 @ 60,000 pph
Turbine	$900,000	0	0	1	2
Condenser	$200,000	0	0	1	1
Ash Handling	$120,000 for #1&#3 $200,000 for #2&#4	-	-	-	-
Refuse Handling	$150,000 for #1&#3 $200,000 for #2&#4	-	-	-	-
Feedwater Heaters	$100,000	2	4	2	4
Coal Handling Equipment	$300,000 for #1&#3 $200,000 for #2&#4	-	-	-	-
Cooling Tower	$100,000	0	0	1	1
Transformer & HV Switchgear	$300,000	0	0	1	1

TABLE D-2

STAFFING REQUIREMENTS FOR PROCESS STEAM PLANT

Job Title	Personnel Per Shift	Total	Annual Rate*	Total
Plant Superintendent	1	1	$22,000	$ 22,000
Control Room Operator	1	5	16,100	80,500
Boiler Operator	1	5	16,100	80,500
Maintenance Man	-	2	13,000	26,000
Coal Pile Operator	1	5	13,000	65,000
Stenographer	-	1	7,000	7,000
Subtotals		19		$ 281,000

* Incl. 30% allowance for payroll taxes and fringe benefits.

TABLE D-3

STAFFING REQUIREMENTS FOR POWER PLANT

Job Title	Personnel Per Shift	Total	Annual Rate	Total
Plant Superintendent	-	1	$ 22,000	$ 22,000
Control Room Operator	1	5	16,100	80,500
Boiler Operator	1	5	16,100	80,500
Turbine Operator	1	5	16,100	80,500
Maintenance Man	-	2	13,000	26,000
Coal Pile Operator	1	5	13,000	65,000
Stenographer	-	1	7,000	7,000
Subtotals		24		$ 361,000